Bulletin British Museum (Natural History)

Entomology Series

VOLUME 58 NUMBER 1 25 MAY 1989

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World List abbreviation: *Bull. Br. Mus. nat. Hist.* (Ent.)

© British Museum (Natural History), 1989

ISBN 0 565 06037 6
ISSN 0524 – 6431

Entomology Series
Vol 58, No. 1, pp. 1 – 130

British Museum (Natural History)
Cromwell Road
London SW7 5BD

Issued 25 May 1989

Typeset by Computer Typesetting Services, Redhill, Surrey
Printed in Great Britain by Henry Ling Ltd, Dorchester, Dorset

Bull. Br. Mus. nat. Hist. (Ent.) **58**(1): 1–78 Issued 25 May 1989

The mealybug genus *Planococcus* (Homoptera: Pseudococcidae)

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Synopsis. Descriptions and illustrations are provided for the 35 species considered here to belong in *Planococcus*, and a key given for their separation. Nine species are newly described and eight new synonymies are proposed. *Dactylopius calceolariae* var. *minor* Maskell from Mauritius, previously regarded as a synonym of Planococcus citri (Risso), is resurrected as *Planococcus minor*, and *P. pacificus* Cox synonymized with it. Five species, previously in *Planococcus*, are transferred to *Planococcoides*, and one species to *Crisicoccus*, as new combinations. Three species of *Crisicoccus*, *C. azaleae* (Tinsley), *C. matsumotoi* (Shiraiwa) and *C. matesovae* Danzig, are illustrated as they might be confused with similar species of *Planococcus*.

INTRODUCTION

Scale insects are amongst the most important pests of agricultural crops, debilitating the plant by loss of sap, contaminating the plant and its fruit with honeydew on which sooty mould frequently grows, transmitting plant viruses, and sometimes injecting toxins that stunt plant growth. Having lifecycles in a warm climate of as little as one month, mealybugs can rapidly attain very high numbers on their hostplant. Fortunately they are usually attacked by a wide range of natural enemies, in particular, encyrtid parasitic wasps and ladybird beetles. Most serious outbreaks of mealybugs occur when they are transported to new countries where their natural enemies do not occur, but in these cases biological control programmes have generally been very effective. Delays in attaining this control, however, have sometimes been caused by initial uncertainty as to the identity, and hence origin, of the mealybug species concerned, as described under the remarks for *Planococcus kenyae* (Le Pelley) below.

The genus *Planococcus* contains a number of well-known mealybug pests including *P. citri* (Risso) on citrus, cocoa and a wide variety of

plants in greenhouses, *P. ficus* (Signoret) on grapevines, figs and pomegranates, *P. kenyae* (Le Pelley) on coffee, and *P. lilacinus* (Cockerell) and *P. minor* (Maskell) on cocoa. *P. vovae* (Nasonov) occurs on *Cupressus* grown as shelter belts in the Mediterranean Basin and might be manipulated as a beneficial insect to encourage the presence of mealybug predators in the vicinity of crops. A number of other species occur on crop plants but are not at present regarded as pests, although this could change should they be introduced to other parts of the world where their natural enemies do not occur. Several of the species revised below are known largely from material intercepted on produce entering the U.K. or U.S.A. These species have considerable potential as future pests but, as their presumed geographical origins are listed here, they would be suitable candidates for biological control.

Planococcus citri is a vector of swollen shoot virus of cacao. However, it is likely that many of the virus-transmission experiments carried out on '*citri*' actually involved *minor*, as these two species were not distinguished until recently.

Some species of *Planococcus* show hostplant specificity at the plant family or genus level. Species of the *dendrobii*-group are apparently specific to Orchidaceae, the *vovae*-group to Cupressaceae, and *P. dubius* Cox to *Dracophyllum* (Epacridaceae). Others, despite having a wide host range, show distinct preferences. For example, *P. citri*, generally regarded as being polyphagous (which it is in greenhouses), is very rarely found out-of-doors on grapevines, while *P. ficus*, common on grapevines, is never found on citrus.

The identification of *Planococcus* species is hindered by the morphological variation that occurs as a result of the conditions under which the individuals develop. Cox (1983) showed *P. citricus* Ezzat & McConnell (1956) to be a high temperature form of *P. citri*. Structural characteristics may vary simply with environmental conditions, or there may be an 'optimum' effect with, for instance, specimens reared at high and low temperatures having few oral collar tubular ducts and specimens reared at medium temperatures having more. The result is that the characteristics distinguishing species may be different for different-sized individuals.

In the absence of live material it has been necessary to resort to multivariate analysis in an attempt to resolve some of the complexes discussed in the present paper.

Study of the current situation has been further confused by the shifting of populations by man - populations that may have been on the verge of speciation have been brought back together again. Thus, although *Planococcus* probably has an Old World origin, six species are now known to occur in the Neotropical Region: *P. citri, P. ficus, P. halli* Ezzat & McConnell, *P. lilacinus, P. minor* and *P. vovae*. All of these species were probably introduced into the Neotropical Region by man.

So much work has been done on this group that the time has come to bring together the available knowledge, and to attempt to resolve some of the remaining species complexes. This study has revealed that the the genus is even more complex than was previously appreciated, and it is apparent that a great deal more experimental work will be necessary to completely elucidate some of the complexes.

Distinction of *Planococcus* from similar genera

Planococcus is not satisfactorily distinguished from other genera. The evolution of mealybugs has apparently involved the loss rather than gain of characters in the adult females, making phylogenetic analysis based on females intractable. Studies of males would probably lead to a better understanding of relationships, but associated males are not available for most species.

One of the consequences of this arbitrary distinction of mealybug genera is that some species of *Planococcus* may be more closely related (by descent) to species currently placed in other genera than they are to other species of *Planococcus*. This is particularly the case with *Crisicoccus* which is distinguished from *Planococcus* only by the loss of some of the cerarii - an occurrence that is likely to have happened more than once. In this paper, such members of *Crisicoccus* that are very similar to species of *Planococcus* have been illustrated.

Cox & Ben-Dov (1986) synonymized *Allococcus* with *Planococcus* and transferred a group of African species previously in *Allococcus* to a new genus, *Delottococcus*. Cox & Freeston (1985) gave characters for distinguishing between the closely related *Planococcus* and *Planococcoides* and transferred *Pseudococcus celtis* Strickland and *Planococcus lamobokensis* Matile-Ferrero to the latter genus. In addition, as mentioned above, *Crisicoccus* is very similar to *Planococcus*. These four genera may be distinguished by the following key.

1 Cerarii numbering less than 18 pairs
CRISICOCCUS Ferris

– Cerarii numbering 18 pairs, although some thoracic pairs may be indistinct 2

2 Circulus absent, translucent pores absent from hind coxae ..... ***DELOTTOCOCCUS*** Cox & Ben-Dov

– Circulus usually present, translucent pores usually present on hind coxae 3

3 All abdominal cerarii anterior to anal lobe pair with only 2 conical setae and without slender auxiliary setae, anal lobe cerarii each with only 2 conical setae ***PLANOCOCCUS*** Ferris

– Some abominal cerarii anterior to anal lobe pair with either more than 2 conical setae or with slender auxiliary setae, anal lobe cerarii each with 2 or more cerarii .. ***PLANOCOCCOIDES*** Ezzat & McConnell

New combinations

The following five species hitherto placed in *Planococcus* are here transferred to *Planococcoides:*

Planococcoides crassus (De Lotto, 1961: 219) (*Planococcus*) **comb. n.**

Planococcoides formosus (De Lotto, 1961: 221) (*Planococcus*) **comb. n.**

Planococcides rotundatus (De Lotto, 1954: 110) (*Planococcus*) **comb. n.**

These three African species are very similar to each other and to *P. celtis* (Strickland) (transferred to *Planococcides* by Cox & Freeston, 1985) in having a rotund body, multilocular disc pores confined to mid-regions of the abdomen, flagellate dorsal setae and large simple pores. They differ from the type species of *Planococcoides, P. njalensis,* by lacking dorsal ducts. Another African species, *P. lamabokensis* (Balachowsky & Ferrero), (also transferred to *Planococcoides* by Cox & Freeston, 1985), does have dorsal tubular ducts and may be a synonym of *P. njalensis.*

Planococcoides anaboranae (Mamet, 1959: 403) (*Planococcus*) **comb. n.**

This species is similar to *Planococcoides lindingeri* (Bodenheimer) from the Mediterranean Basin, which was transferred to *Planococcoides* by Cox & Ben-Dov (1986).

Planococcoides mumensis (Tang, 1977: 34) (*Planococcus*) **comb. n.**

This species was described from the leaves of *Prunus mume* in the Zhejiang Province of China. Although it was not possible to obtain specimens of *P. mumensis* for examination, Professor Tang kindly provided an English translation of his original description and a further illustration. From these it is apparent that this species has auxiliary setae in all of the cerarii, the anal lobe cerarii each have 2 or 3 conical setae, multilocular disc pores are confined to the median areas of the posterior abdominal segments, and tubular ducts are confined to the posterior abdominal segments of the venter. Consequently, *Planococcus mumensis* is here transferred to *Planococcoides.*

Also currently included in *Planococcoides* are *P. ireneus* De Lotto from the Afrotropical Region, *Planococcoides robustus* Ezzat & McConnell from India, and *P. pauliani* Mamet from Madagascar.

Crisicoccus matesovae (Danzig, 1986: 21) (*Planococcus*) **comb. n.**

Checklist of species here included in *Planococcus*

This list includes new combinations, new synonymies, distributions and hostplant preferences where known. The original generic names, if these are not *Planococcus,* are given in parenthesis.

aemulor De Lotto, 1964.
Afrotropical Region, on *Combretum spendens* and *Asparagus* sp.

aphelus De Lotto, 1967.
Afrotropical Region, on *Phylica* sp.

boafoensis (Strickland, 1947) (*Tylococcus*).
Afrotropical Region, on *Musanga* spp.

citri (Risso, 1813) (*Dorthesia*).
Phenacoccus spiriferus Hempel, 1900. **Syn. n.**
Planococcoides cubanensis Ezzat & McConnell, 1956. **Syn. n.**
Planococcus cucurbitae Ezzat & McConnell, 1956. **Syn. n.**
Cosmopolitan, on many hostplants, especially citrus, coffee and cocoa.

dendrobii Ezzat & McConnell, 1956.
Oriental Region, on orchids.

dioscoreae Williams, 1960.
Austro-oriental Region, usually on yams.

dorsospinosus Ezzat McConnell, 1956.
Planococcus myrsinephilus Borchsenius, 1962. **Syn. n.**
Planococcus sinensis Borchsenius, 1962. **Syn. n.**
Palaearctic, Oriental and Austro-oriental Regions, on a variety of trees.

dubius Cox, 1987.
New Zealand, on *Dracophyllum.*

epulus De Lotto, 1964.
Afrotropical Region, on *Pterolobium lacerans.*

ficus (Signoret, 1875) (*Dactylopius*).
Dactylopius subterraneus Hempel, 1901. **Syn. n.**
Palaearctic, Afrotropical, Oriental and Neotropical Regions, on a variety of hostplants, especially grapevines, figs and pomegranates.

flagellatus De Lotto, 1961.
Afrotropical Region, on a variety of hosts.

furcisetosus Mamet, 1959.
Malagasian Region, on *Diospypros* sp.

halli Ezzat & McConnell, 1956.
Neotropical and Afrotropical Regions, on a variety of hostplants, especially yams.

hospitus De Lotto, 1961.
Afrotropical Region, on orchids.

hosyni Ezzat & McConnell, 1956.
Afrotropical Region on orchids.

japonicus sp. n.
Japan (frequently intercepted in the U.S.A.), on a variety of trees, including loquat.

kenyae (Le Pelley, 1935) (*Pseudococcus*).
Planococcus subukiaensis De Lotto, 1954. **Syn. n.**
Afrotropical Region, on a variety of hostplants, especially coffee and cocoa.

kraunhiae (Kuwana, 1902) (*Dactylopius*).
Planococcus siakwanensis Borchsenius, 1962. **Syn. n.**
Palaearctic, Oriental and Nearctic Regions, on a variety of trees, including citrus.

lilacinus (Cockerell, 1905) (*Pseudococcus*).
Pseudococcus deceptor Betrem, 1937. **Syn. n.**
Malagasian, Oriental, Austro-oriental and Neotropical Regions, on a variety of hostplants including citrus, guava, cocao, coffee, custard apple and mango.

litchi sp. n.
Palaearctic, Oriental and Austro-oriental Regions (all interceptions in the U.K. or U.S.A.), on lychee and loquat.

mali Ezzat & McConnell, 1956.
New Zealand and Australia, on a variety of woody hostplants, especially apple and blackcurrant.

martini sp. n.
Austro-oriental Region, on Araceae.

minor (Maskell, 1897) (*Pseudococcus*). **Nom. rev., stat. n., comb. n.**
Planococcus pacificus Cox, 1981. **Syn. n.**
Oriental, Austro-oriental, Australian, Polynesian, Neotropical and Malagasian Regions, on a wide variety of hostplants including cocoa and coffee.

morrisoni (Ezzat & McConnell, 1956) (*Allococcus*).
Oriental and Austro-oriental Regions (all intercepted in the U.S.A.), on mangosteen, lychee, *Lansium domesticum* and *Melicoccus bijugatus*.

nigritulus De Lotto, 1961.
Afrotropical Region, on *Phoenix dactylifera* and *Ficus* sp.

orchidi sp. n.
Afrotropical Region, on orchids.

philippinensis Ezzat & McConnell, 1956.
Austro-oriental Region, on orchids.

principe sp. n.
Afrotropical Region, on cocoa.

psidii sp. n.
Austro-oriental Region, on *Psidium guajava*.

subterraneus De Lotto, 1964.
Afrotropical Region, on *Ficus* sp.

sulawesi sp. n.
Austro-oriental Region, on Urticaceae.

taigae Danzig, 1986.
Palaearctic Region, on Cupressaceae.

tanzaniensis sp. n.
Afrotropical Region, on *Hevea braziliensis*.

vovae (Nasonov, 1908) (*Pseudococcus*).
Palaearctic and Neotropical Regions, on Cupressaceae.

zairensis sp. n.
Afrotropical Region.

Species-groups in *Planococcus*

Several, apparently monophyletic, species-groups can be distinguished amongst this assemblage of species. The *citri*-group contains those species which have marginal multilocular disc pores on the abdominal venter, tubular ducts on the venter of all abdominal segments and on the head and thorax, and flagellate dorsal setae. As it contains the type-species of the genus, this group constitutes *Planococcus* sensu stricto, and includes *P. aphelus, P. citri, P. epulus, P. ficus, P. flagellatus, P. halli, P. minor, P. nigritulus, P. subterraneus, P. tanzaniensis* and probably *P. aemulor* and *P. kenyae*. *P. aemulor* lacks tubular ducts on the head and thorax, while *P. kenyae* lacks marginal multilocular disc pores and, in small specimens, it sometimes also lacks tubular ducts on the head and thorax. All of these species, except *P. minor*, occur in the Mediterranean Basin or the Afrotropical Region, although *P. citri, P. ficus* and *P. halli* have been transported to other parts of the world. The geographical origin of *P. minor* is not clear - its current distribution includes the South Pacific, the Oriental, Austro-oriental, Australian, Malagasian and Neotropical Regions.

Another group, the *dendrobii*-group, contains eight species of which five have been found only on Orchidaceae. All eight species are rotund, have stout legs and have the multilocular disc pores and tubular ducts confined to the posterior abdominal segments. All of the orchid-feeding species have knobbed dorsal setae. Two of these species, *P. dendrobii* and *P. philippinensis*, are from the Oriental Region, and 3 species, *P. hospitus, P. hosyni* and *P. orchidi*, are from the Afrotropical Region. *P. zairensis* from an unknown hostplant in Zaire and *P. martini* from Araceae in Indonesia are similar to the above

species, but lack knobbed dorsal setae. *P. furcisetosus* from ebony in Madagascar differs from the orchid-feeding species only by having furcate dorsal setae. *P. principe* may belong in this group, but this species has a few marginal multilocular disc pores. The body shape and distributions of the multilocular disc pores and tubular ducts of the *dendrobii*-group are similar to those found in most species of *Planococoides* and it may not be a genuine component of *Planococcus*.

A third group, the *dorsospinosus*-group, comprises those species which lack marginal multilocular disc pores and have conical dorsal setae with associated aggregations of trilocular pores. These species are from the Oriental and Austro-oriental Regions and Japan. The *dorsospinosus*-group comprises *P. dioscoreae, P. dorsospinosus* and *P. litchi. P. sulawesi* clearly also belongs to this group, but in this species the enlarged dorsal setae are very long and flagellate. *P. krauhniae* from Japan and *P. psidii* from West Malaysia may also belong to this group, but both have marginal multilocular disc pores and the trilocular pores are not as obviously associated with the enlarged dorsal setae as in the above-mentioned species.

The two species of the *vovae*-group, *P. taigae* and *P. vovae,* are both confined to Cupressaceae. Each has a distinct geographical range, *P. vovae* occurring in central and southern Europe, the Caucasus and montane Central Asia (also Brazil), and *P. taigae* in the north-eastern parts of the Palaearctic Region. These species are characterized by their flagellate cerarian setae, numerous dorsal tubular ducts, and by lacking marginal multilocular disc pores. Otherwise, they are similar to the *P. citri*-group. *Crisicoccus matesovae,* known only from Cupressaceae in Altai, U.S.S.R., is very similar to both of these species, but has fewer than 18 pairs of cerarii and has consequently been transferred from *Planococcus* to *Crisicoccus* (see above).

The remaining group that can be distinguished is the *mali*-group comprising *P. japonicus, P. mali,* and perhaps *P. morrisoni.* These species are characterized by having short, stout, almost conical, dorsal setae and a marginal group of tubular ducts adjacent to the anterior spiracles, while these ducts are absent, or in very low numbers, on the margins of the head and mesothorax. In addition, *P. japonicus* and *P. mali* both have more than 2 conical setae in most of the cephalic and thoracic cerarii. *P. japonicus* is known only from Japan, *P. mali* only from Australia and New Zealand (although its true origin may lie closer to Japan - see under remarks for this species), and *P. morrisoni* is from the Oriental Region. In *P. mali,* some of the pairs of cerarii may be indistinct or apparently absent, making it appear to be a member of *Crisicoccus,* although most specimens have a full complement of 18 pairs of cerarii. Both *P. japonicus* and *P. mali* are similar to species of *Crisicoccus,* such as *C. azaleae* (Tinsley) and *C. matsumotoi* (Shiraiwa), and may, in fact, be more closely related to these species than to the *P. citri*-group. *C. azaleae* and *C. matsumotoi* have been illustrated in this work to allow the easy distinction of these species.

A few remaining species have no obvious affinities with any of the above groups. *P. boafoensis,* from the Afrotropical Region, is remarkable in having the cerarii situated on protuberances, but otherwise has very reduced numbers of multilocular disc pores and tubular ducts and has short, stout, dorsal setae. It is perhaps closest to the *dendrobii*-group. The Oriental *P. lilacinus* is an enigma, having a rotund body, stout legs, reduced numbers of multilocular disc pores, but tubular ducts extending around the margins of the entire body. The dorsal setae are very long, and quite stout. The true origin of this species may be from outside the genera discussed here.

From the above it can be seen that the species of *Planococcus* revised in this work almost certainly do not comprise a monophyletic group. However, the prime purpose of this study is not to propose a generic system based on phylogenetic relationships, but to provide a means for the identification of a group of similar looking species, many of which are real or potential pests of economically important plants. To this end, illustrations have been provided of some similar (and perhaps related) species currently placed in other genera with which some of the species covered here might be confused.

Terminology

The major characters used are illustrated in Fig. 1. Cerarii are counted starting at the anterior end. Abdominal segments are counted in such a way that the circulus lies between segments III and IV, and the vulva lies between segments VII and VIII. Although the translucent pores on the hind legs usually occur on the hind surface, and hence would be hidden in the illustrations as presented, they have been illustrated here as if they are on the frontal surface of the legs. Numbers of pores and ducts, when given in the text, are totals of both sides of the body - mealybugs are frequently not symmetrical in the distribution of their characters.

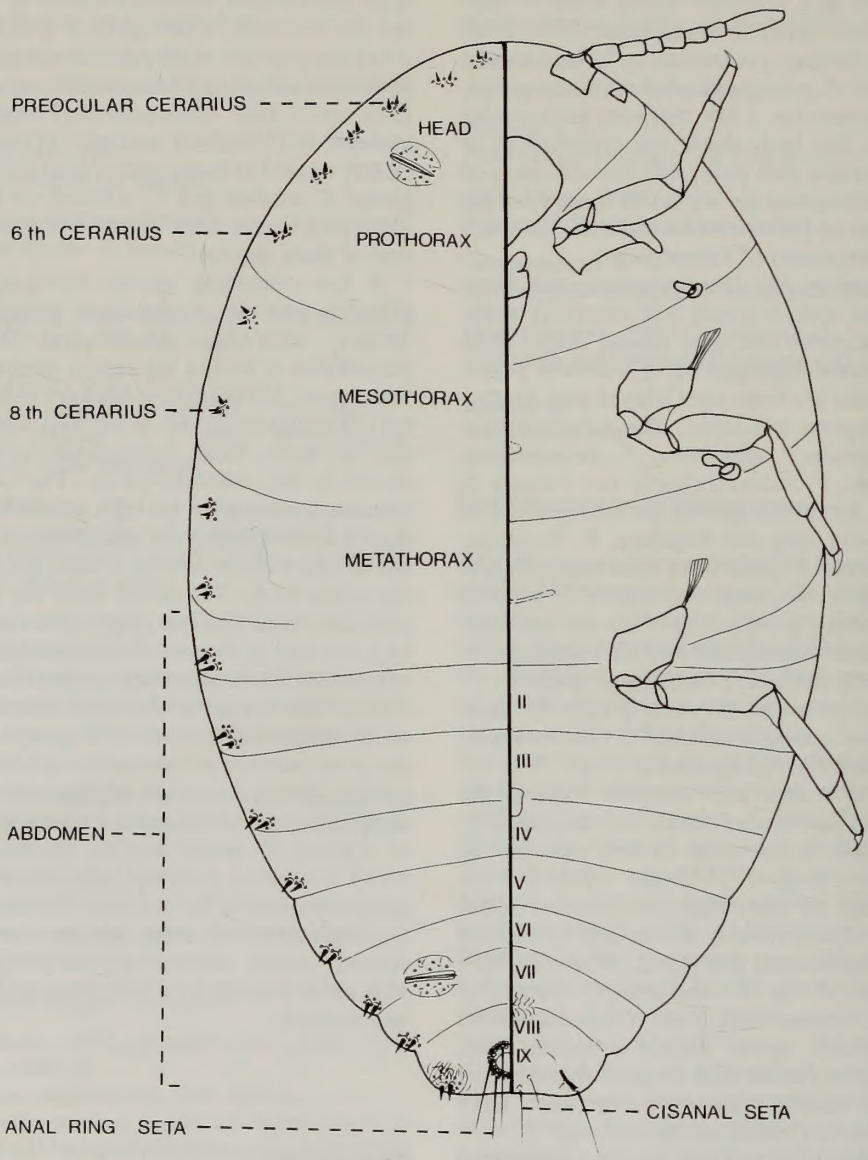

Fig. 1 Generalized diagram of *Planococcus* sp. showing numbering of body segments and cerarii.

Depositories

BMNH British Museum (Natural History), London, U.K.

IBSP Instituto Biologico de São Paulo, Brazil.

MNHN Muséum National d'Histoire Naturelle, Paris, France.

MZSP Museu de Zoologia, Universidade de São Paulo, Brazil.

NZAC New Zealand Arthropod Collection, Auckland, New Zealand.

SANC South African National Collection of Insects, Pretoria, South Africa.

UCD University of California, Davis, U.S.A.

USNM United States National Museum, Washington D.C., U.S.A.

VCCB Vernalna Collection, Universidade Federal do Parana, Curitiba, Brazil.

VCI Coccoidea Collection, Department of Entomology, The Volcani Center, Bet Dagan, Israel.

ZIL Zoological Institute, U.S.S.R. Academy of Sciences, Leningrad, U.S.S.R.

Acknowledgements

I thank Dr E. M. Danzig (ZIL), Mme D. Matile-Ferrero (MNHN), Dr D. R. Miller, Mr S. Nakahara and Mr V. L. Blackburn (United States Department of Agriculture), Mrs C. F. Morales (NZAC), Mr R. D. Schuster (UCD) and Dr Yair Ben-Dov (VCI) for the loan of specimens; and my colleagues, especially Dr D. J. Williams, for helpful advice and criticism. Figs 11 and 14 are reproduced with the permission of *Bulletin of Entomological Research*, and Figs 20, 22 and 27 with the permission of *Journal of Natural History*.

SYSTEMATICS

PLANOCOCCUS Ferris

Planococcus Ferris, 1950: 164. Type-species: *Dactylopius citri* Risso, by original designation.
Allococcus Ezzat McConnell, 1956: 13. Type-species: *Pseudococcus inamabilis* Hambleton, by original designation. [Synonymy by Cox & Ben-Dov, 1986.]

ADULT FEMALE. Body shape oval to rotund. Cerarii numbering 18 pairs, thoracic cerarii indistinct in some specimens of a few species, but other specimens of that species having the full number; abdominal cerarii each with 2 conical setae and several long flagellate auxiliary setae, thoracic and remaining abdominal cerarii each with only 2 conical or flagellate setae and without auxiliary setae, cephalic cerarii each with 1-5 conical or flagellate setae. Circulus usually present, quadrate in most species, but small and round in some species. Legs well-developed in most species, but short and stout in some species; translucent pores usually present on hind coxae and tibiae only, sometimes present also on hind femora in *P. ficus*, absent from the hind tibiae in *P. dendrobii* and *P. philippinensis* and apparently completely absent from the hind legs in *P. aemulor* and *P. hospitus*; claw without denticle. Anal lobe bars always apparent. Anal ring of usual pseudococcid form, with 6 long setae.

Multilocular disc pores usually confined to venter, although present on dorsum in *P. epulus* and *P. dubius*; always present in at least single rows across posterior borders of mid-regions of posterior abdominal segments, variably present on head, thorax, anterior borders of abdominal segments and margins of abdominal segments. Trilocular pores usually evenly distributed, but aggregated around bases of enlarged dorsal setae in the *dorsospinosus*-group. Tubular ducts generally of the oral collar type, sparse to numerous on the venter, sometimes present on the dorsum where they may appear to have rims. Simple pores generally smaller than the trilocular pores, but larger in some species; often aggregated in groups on the dorsal mid-regions of the anterior abdominal segments. Setae long, fine and flagellate on median areas of venter; variable on dorsum, flagellate in the *citri*- and *vovae*-groups, stout, almost lanceolate, in the *mali*-group, conical in the *dorsospinosus*-group and knobbed in the dendrobii-group; setae on the marginal areas of the venter often similar to those on the dorsum.

Key to species of *Planococcus*

1 Multilocular disc pores present on dorsum 2
– Multilocular disc pores absent from dorsum ... 3
2 Most cephalic and thoracic cerarii each with three conical setae, dorsal setae stout, found in New Zealand only (Fig. 9) ..... ***dubius***
– Most cephalic and thoracic cerarii each with 2 conical setae, dorsal setae slender, found in Kenya only (Fig. 10) ..... ***epulus***
3 All cerarii situated on very pronounced sclerotized protuberances, tubular ducts and multilocular disc pores few in number and restricted to median areas of the posterior abdominal segments, dorsal setae short and stout, almost lanceolate, known only from the Afrotropical Region (Fig. 4) . ***boafoensis***
– Cerarii not situated on protuberances, although very young adults may sometimes give this appearance, other characters various 4
4 Anal lobe cerarii each situated on a large, prominent, sclerotized area, body oval to rotund, cisanal setae longer than anal ring setae, multilocular disc pores very few or absent on margins and on anterior edges of median areas of abdominal segments, dorsal tubular ducts absent, ventral tubular ducts present in marginal groups on all abdominal segments, often also present on head and thorax, found in the Afrotropical Region (Fig. 20) ..... ***kenyae***
– Anal lobe cerarii situated on small, not particularly prominent, sclerotized areas, other characters various 5
5 Oral collar tubular ducts absent from both median and marginal areas of head and thorax 6
– Oral collar tubular ducts usually present on median areas of thorax, if absent, then present on margins of head and thorax 14
6 Many dorsal setae furcate, found in Madagascar only (Fig. 13) ..... ***furcisetosus***
– Dorsal setae never furcate 7

7 Ventral simple pores as large as the multilocular disc pores, known only from Uganda (Fig. 15) ***hospitus***

– Ventral simple pores, if apparent, considerably smaller than the multilocular disc pores 8

8 No more than 1 tubular duct present on each side of each abdominal segment, known only from the Afrotropical Region 9

– Tubular ducts present in small groups on either side of abdominal segments VI and VII, known from the Afrotropical, Oriental and Austro-oriental Regions 10

9 Dorsal setae short and stout, tubular ducts and multilocular disc pores usually present singly on margins of some posterior abdominal segments (Fig. 40) ..... ***zairensis***

– Dorsal setae moderately long and fine, margins of abdominal segments never with tubular ducts or multilocular disc pores, known only from the Afrotropical Region (Fig. 16) ..... ***hosyni***

10 Margins of posterior abdominal segments each with a few multilocular disc pores, translucent pores absent from hind legs, dorsal setae not knobbed, known only from Kenya (Fig. 2) ..... ***aemulor***

– Margins of abdominal segments without multilocular disc pores, translucent pores present on hind coxae, often also on hind tibiae, dorsal setae sometimes knobbed 11

11 Dorsal setae not knobbed, antennae 7-segmented, known only from Indonesia (Fig. 26) .... ***martini***

– Dorsal setae distinctly knobbed, antennae 8-segmented 12

12 Simple pores on venter very conspicuous and about twice the size of the trilocular pores, translucent pores present on hind tibiae, known only from Liberia (Fig. 30) ..... ***orchidi***

– Simple pores inconspicuous and about half the size of the trilocular pores, translucent pores absent from hind tibiae, found in the Oriental and Austro-oriental Regions 13

13 Circulus present, cisanal setae shorter or about the same length as the anal ring setae, simple pores on mid-region of dorsum smaller than the trilocular pores (Fig. 6) ..... ***dendrobii***

– Circulus absent, cisanal setae longer than the anal ring setae, simple pores on mid-region of dorsum, particularly on the posterior segments, larger than the trilocular pores (Fig. 31) ..... ***philippinensis***

14 Tubular ducts with pronounced oral rims present on dorsum adjacent to several cerarii and scattered over median area of dorsum, dorsal setae short and stout, almost lanceolate, found in the Oriental and Austro-oriental Regions (Fig. 28) ..... ***morrisoni***

– If more than 2 oral rim tubular ducts present on dorsum, then dorsal setae long and slender ... 15

15 Several cephalic and thoracic cerarii usually each with more than 2 conical setae, some thoracic and anterior cerarii usually indistinct and with only 1 conical seta 16

– Cephalic and thoracic cerarii each with only two conical setae, except for preocular pair which sometimes have three conical setae in each cerarius, all cerarii distinct and with 2 conical setae 17

16 Number of ventral tubular ducts on margins of prothorax totalling 0–45, length of hind tibia + tarsus 305–410 μm, known only from Australia and New Zealand (Fig. 24) ..... ***mali***

– Number of ventral tubular ducts on margins of prothorax totalling 24–63, length of hind tibia + tarsus 235–315 μm, known only from Japan (Fig. 17) ***japonicus***

17 Multilocular disc pores present on margins of abdominal segments, even if only 1 or 2 per segment 18

– Multilocular disc pores completely absent from margins of abdominal segments 26

18 Many simple pores on both venter and dorsum almost as large as the multilocular disc pores, known only from Principe (Fig. 32) ..... ***principe***

– Simple pores on both venter and dorsum never more than twice the size of the trilocular pores 19

19 Dorsal setae with distinctly swollen bases, multilocular disc pores very sparse on margins of abdominal segments, oral collar tubular ducts on dorsum in groups of 2–5 ducts adjacent to some abdominal cerarii, found in Japan and U.S.A. (Fig. 21) ***kraunhiae***

– Dorsal setae without swollen bases, multilocular disc pores moderately numerous on margins of abdominal segments, tubular ducts, if present on dorsum, usually present singly adjacent to cerarii 20

20 Circulus absent, known only from South Africa (Fig. 3) ..... ***aphelus***

– Circulus present 21

21 Oral collar tubular ducts absent from abdominal segments IX, and often also from VIII, body broadly oval to rotund, ventral simple pores at least same size as the trilocular pores, dorsal setae stout, found only in the Afrotropical Region 22

– Oral collar tubular ducts present on venter of both abodominal segments VIII IX, body elongate-oval to broadly oval, simple pores smaller than the trilocular pores, dorsal setae slender, widely distributed 23

22 Oral collar tubular ducts present on ventral, median areas of thorax, tubular ducts usually present on venter of abdominal segment VIII, simple pores about the same size as the trilocular pores (Fig. 38) ***tanzaniensis***

– Oral collar tubular ducts absent from median areas of thorax, although present on margins of head and thorax, tubular ducts absent from both abdominal segments VIII IX, ventral simple pores about twice the size of the trilocular pores (Fig. 29) ***nigritulus***

23 Dorsal setae long and fleshy, longest setae on abdominal segment VI or VII up to 100 μm long, sometimes strongly bifurcate 24

– Dorsal setae either short (less than 30 μm long) or if longer, then slender, never fleshy or bifurcate 25

24 Several dorsal setae strongly bifurcate, oral collar tubular ducts absent from head, known only from South Africa (Fig. 34) ..... ***subterraneus***

– No more than 2 dorsal setae bifurcate, at least 4 oral collar tubular ducts present on head, found in the Afrotropical Region (Fig. 12) ..... ***flagellatus***

25 Head with 0–35 oral collar tubular ducts, longest seta on median area of abdominal segment VI or VII 17–33 μm long, cerarian setae on head and thorax always conical, dorsum rarely with more than 6 oral collar tubular ducts, median ventral area of abdominal segment VII with a single or double row of multilocular pores, translucent pores never present on hind femora 26

– Head with 0–4 oral collar tubular ducts, longest seta on median area of abdominal segment VI or VII 25–50 μm long, cerarian setae on head and thorax often long and slender, dorsum with 0–20 oral collar tubular ducts, median ventral area of abdominal segment VII usually with a single row of multilocular disc pores, translucent pores sometimes present on hind femora 27

26 Dorsal setae blunt-ended, translucent pores on hind legs noticeably large and distinct, known only from West Malaysia (Fig. 33) ..... ***psidii***

– Dorsal setae flagellate, translucent pores on hind legs typical of genus, worldwide (see Table 1) ***citri/minor***

27 Translucent pores often apparent on one or both hind femora; total number of multilocular disc pores behind the front coxae 0–17; rows of median multilocular disc pores usually present on abdominal segments IV-VII, sometimes also on III; 1 or 2 multilocular disc pores usually present on each margin of abdominal segments II and III; common on grapevines in the Mediterranean Basin, Pakistan, Argentina and South Africa (Fig. 11) ..... ***ficus***

– Translucent pores absent from hind femora; multilocular disc pores behind front coxae totalling 0–5; rows of multilocular disc pores present on abdominal segments III-VII, often also on II; multilocular disc pores seldom present on margins of abdominal segment II, sometimes present on margins of III; common on *Dioscorea* spp. in the West Indies and the Afrotropical Region (Fig. 14) ..... ***halli***

Table 1 Separation of *P. citri* and *P. minor*.

Character	Value	Score
(All numbers are the totals from both sides of the body)		
A. Number of ventral tubular ducts on head	0–3	0
	4–13	10
	14–35	40
B. Number of ventral tubular ducts adjacent to 8th pair (numbering from the anterior) of cerarii	0–2	0
	3–7	10
	8–30	40
C. Tubular ducts present between 2nd and 3rd cerarii on head on at least one side of the body	yes	10
	no	0
D. Number of multilocular disc pores behind front coxae	0–6	5
	7–12	0
E. Ratio of length of hind tibia + tarsus to length of trochanter + femur	1.00–1.07	0
	1.08–1.17	5
	1.18–1.30	10
F. Width of row of multilocular disc pores on posterior margin of abdominal segment VI	single row	15
	intermediate	5
	double row	0

Scores: 0–35 = *minor* (Fig. 27) (p. 000)
35–120 = *citri* (Fig. 5) (p. 000)

28 Cephalic cerarian setae flagellate, dorsal tubular ducts in rows across posterior abdominal segments, on Cupressacae 29

– Cephalic cerarian setae usually conical, dorsal tubular ducts, if present, occurring singly adjacent to cerarii, not found on Cupressaceae 30

29 Dorsal tubular ducts in rows of up to 24 ducts across posterior abdominal segments, total of more than 200 ducts on dorsum, found in the eastern Palaearctic Region (Fig. 36) ..... ***taigae***

– Dorsal tubular ducts in rows of no more than 18 ducts across posterior abdominal segments, total of 13–110 ducts on dorsum, widespread in the western Palaearctic Region and also in Brazil (Fig. 39) ***vovae***

30 All dorsal setae noticeably long and flagellate, longest seta on abdominal segment VI or VII 50–140 μm long, with or without trilocular pores associated with their bases 31

– Most dorsal setae conical, some almost as large as cerarian setae, and with one or more trilocular pores associated with their bases 32

31 Legs noticeably short and stout, ratio of hind tibia + tarsus to hind trochanter + femur 0.77–0.97; dorsal setae without trilocular pores associated with their bases; found in the Oriental, Austro-oriental, Malagasian and Neotropical Regions (Fig. 22) ***lilacinus***

– Legs elongate, ratio of hind tibia + tarsus to hind trochanter + femur 1.06–1.07; larger dorsal setae with one or more trilocular pores associated with their bases; known from Indonesia only (Fig. 35) ***sulawesi***

32 Several dorsal setae associated in pairs (Fig. 23) ***litchi***

– Dorsal setae not in pairs 33

33 Ventral tubular ducts adjacent to eyes totalling 6–22, found in Papua New Guinea and the Solomon Islands, usually on *Dioscorea* sp. (Fig. 7) ***dioscoreae***

– Ventral tubular ducts adjacent to eyes totalling no more than 7, known only from Japan and the Oriental Region on a variety of hosts (Fig. 8) ***dorsospinosus***

Descriptions of species

Planococcus aemulor De Lotto

(Fig. 2)

Planococcus aemulor De Lotto, 1964: 372. Holotype ♀, KENYA: on *Combretrum splendens* (BMNH) [examined].

ADULT FEMALE. Mounted specimens broadly oval, length 1.6–1.9 mm, width 1.1–1.4 mm. Antennae 7- or 8-segmented, if 7-segmented, then pseudoarticulation apparent on segment IV. Margin of body with complete series of 18 pairs of cerarii, each cerarius with 2 (rarely 3 on head) slender conical setae. Legs elongate; hind trochanter + femur 255–280 μm long, hind tibia + tarsus 265–285 μm long, ratio of lengths of hind tibia + tarsus to hind trochanter + femur 1.00–1.07; translucent pores not apparent on hind legs. Inner edges of ostioles moderately sclerotized. Circulus large and probably quadrate, although generally distorted in mounted specimens, width 170–200 μm. Cisanal setae shorter than anal ring setae. Anal lobe area apparently only slightly sclerotized.

Venter. Multilocular disc pores moderately numerous around vulva, present in single rows across posterior edges of median areas of abdominal segments III-VII or IV-VII, a few pores present on anterior edge of median area of segment VII and on margins of at least some posterior segments. Trilocular pores numerous and evenly distributed. Oral collar tubular ducts, apparently of 1 size and confined to the abdomen, present sparsely in rows across median areas of abdominal segments III-VII and in marginal groups on segments IV-VIII, but usually absent from segments VIII or IX. Simple pores slightly larger than the trilocular pores, sparsely scattered over venter.

Dorsum. Multilocular disc pores and tubular ducts absent. Trilocular pores as for venter. Simple pores of 2 sizes, larger pores as for venter, smaller pores about a third of the size of the trilocular pores, sparsely scattered over dorsum. Setae stout, blunt-ended and moderately short, longest seta on abdominal segments VI or VII 25–35 μm long.

MATERIAL EXAMINED

Holotype ♀, **Kenya**: Ruiru, on *Combretum splendens*, 20.viii.1957 (*R. H. Le Pelley*) (BMNH). 6 paratype ♀, same data as holotype (BMNH).

DISTRIBUTION. Afrotropical Region: Kenya.

HOSTPLANTS. Combretaceae: *Combretum splendens*. Also recorded from *Asparagus* sp. (Liliaceae) (De Lotto, 1964).

REMARKS. *P. aemulor* resembles *P. nigritulus* in lacking tubular ducts on the median areas of the thoracic venter and in usually lacking ducts on abdominal segments VIII andIX. The two species may be distinguished by the presence of marginal ventral tubular ducts on the head and thorax and translucent pores on the hind coxae and tibiae in *P. nigritulus*, both of which characters are lacking

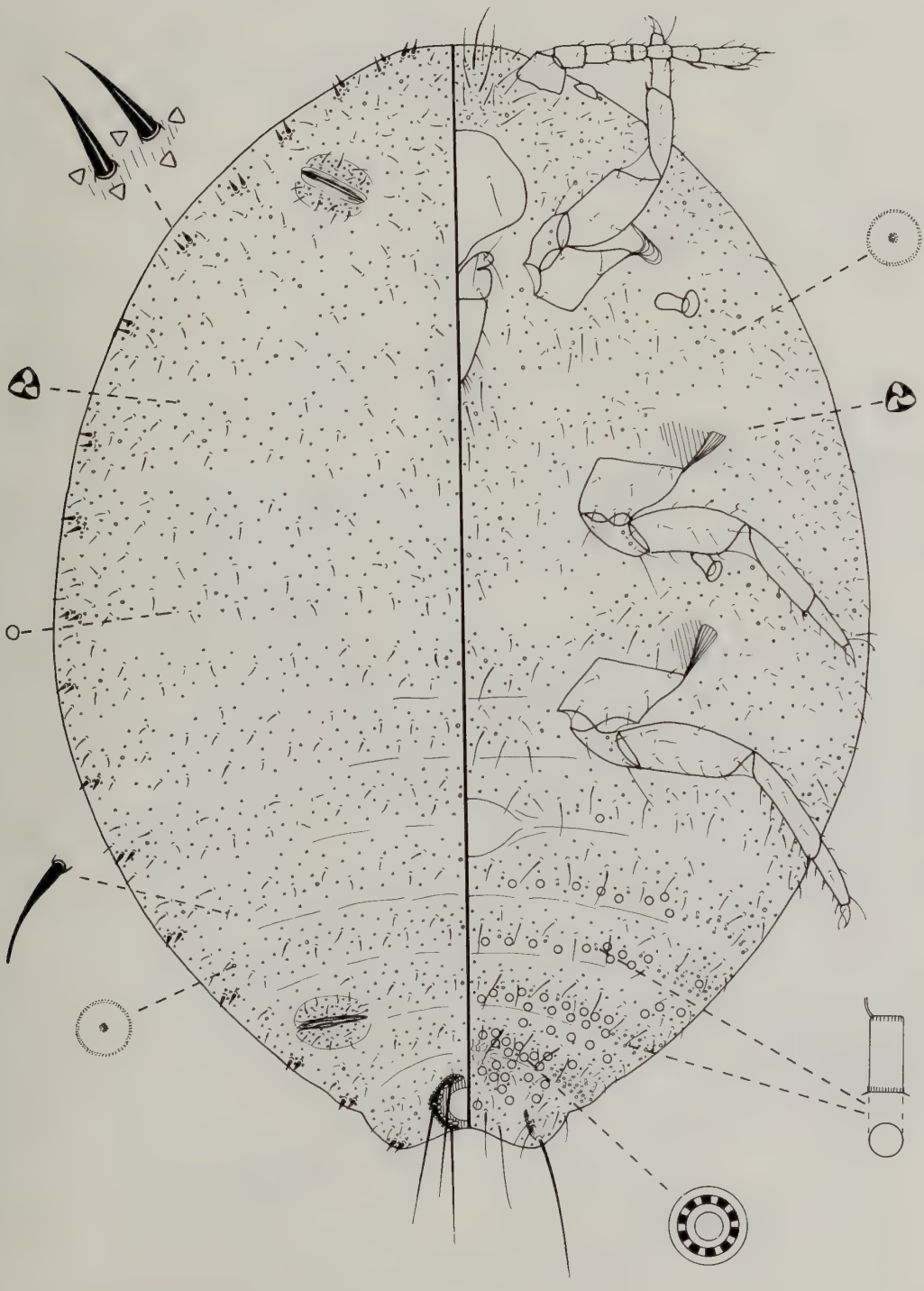

Fig. 2 *Planococcus aemulor* De Lotto.

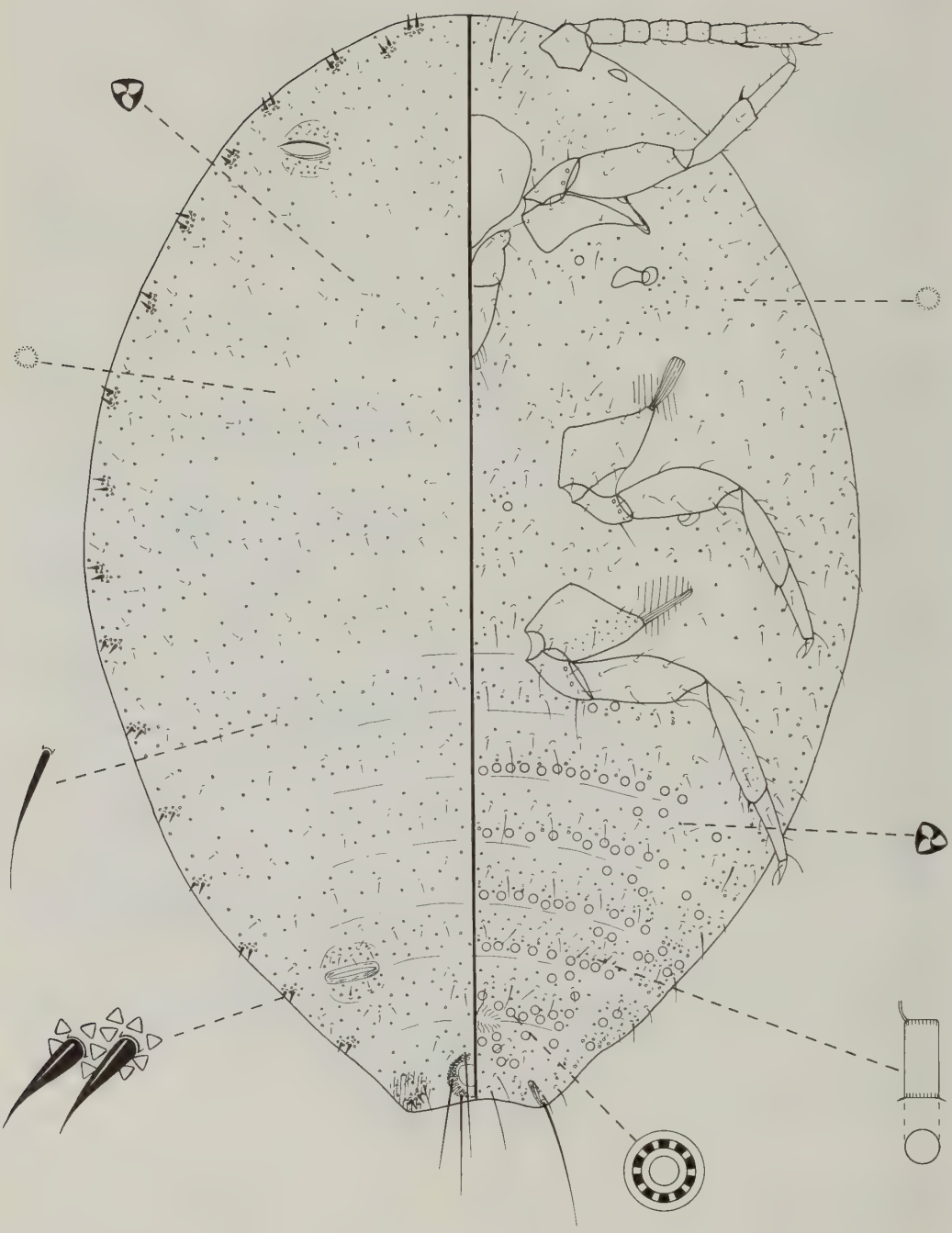

Fig. 3 *Planococcus aphelus* De Lotto.

from *P. aemulor*. The complete lack of tubular ducts on the thorax in *P. aemulor* together with the short, stout, blunt-ended dorsal setae indicate that it may be related to the orchid-feeding *dendrobii*-group rather than to the *citri*-group.

The only other known species of *Planococcus* completely lacking translucent pores on the hind legs is *P. hospitus*.

Planococcus aphelus De Lotto

(Fig. 3)

Planococcus aphelus De Lotto, 1967: 16. Holotype ♀, SOUTH AFRICA: on roots of *Phylica* sp. (SANC) [not examined].

ADULT FEMALE. Mounted specimens oval, length about 1.4 mm, width about 0.9 mm. Antennae 7- or 8-segmented, if 7-segmented, then pseudoarticulation apparent on segment IV. Margin of body with complete series of 18 pairs of cerarii, each cerarius with 2 slender conical setae. Legs elongate; hind trochanter + femur 230–265 μm long, hind tibia + tarsus 230–280 μm long, ratio of lengths of hind tibia + tarsus to hind trochanter + femur about 1.06; translucent pores apparent on hind coxae and tibiae. Inner edges of ostioles moderately sclerotized. Circulus absent. Cisanal setae shorter than anal ring setae. Anal lobe cerarii each situated on a moderately sized, moderately sclerotized area.

Venter. Multilocular disc pores present sparsely around vulva, in single rows across posterior edges of abdominal segments II-VII, a few present on anterior edges of segments V-VII, present singly or in small groups on margins of at least some abdominal segments, and sparsely scattered over median areas of thorax. Trilocular pores moderately numerous and evenly distributed. Oral collar tubular ducts apparently of 1 size, present sparsely in rows across median areas of abdominal segments II-VII, in small marginal groups on segments II-VIII, scattered over median area of thorax, and present singly on the margins of some thoracic segments. Simple pores considerably smaller than the trilocular pores, sparsely but evenly distributed.

Dorsum. Multilocular disc pores and tubular ducts absent. Trilocular pores and simple pores as for venter. Setae flagellate and of moderate length, longest seta on abdominal segments VI or VII 25–35 μm long.

MATERIAL EXAMINED

South Africa: 2 paratype ♀, Cape Province, Somerset West, on roots of *Phylica* sp., 26.xi.1964 (*J. Munting*) (BMNH).

DISTRIBUTION. Afrotropical Region: South Africa.

HOSTPLANT. Rhamnaceae: *Phylica* sp.

REMARKS. The distribution of the multilocular disc pores shows this species to be a member of the *citri*-group. It differs from the other members of this group by lacking a circulus.

Planococcus boafoensis (Strickland)

(Fig. 4)

Tylococcus boafoensis Strickland, 1947: 151; Williams, 1958: 30. Syntypes ♀, GHANA: on *Musanga smithii* (BMNH) [11 syntypes examined].

Planococcus boafoensis (Strickland) De Lotto, 1964: 372.

ADULT FEMALE. Mounted specimens elongate-oval, length 1.3–2.2 mm, width 0.6–1.3 mm. Margin of body with complete series of 18 pairs of cerarii situated on sclerotised protuberances, each cerarius with 2 (sometimes 3 on head and/or thorax) slender conical setae. Legs elongate; hind trochanter + femur 215–265 μm long, hind + tibia tarsus 225–275 μm long, ratio of lengths of hind + tibia tarsus to hind trochanter + femur 1.04–1.08; translucent pores apparent on hind coxae and tibiae. Inner edges of ostioles lightly sclerotized. Circulus quadrate or oval, width 50–70 μm. Cisanal setae shorter than anal ring setae.

Venter. Multilocular disc pores confined to median areas of abdomen, sparsely present around vulva and in a single row across posterior edge of abdominal segment VI. Trilocular pores very sparse and evenly distributed. Oral collar tubular ducts of 1 size, confined to abdomen, a few present on median areas and margins of abdominal segments VI or VII. Simple pores apparently absent.

Dorsum. Multilocular disc pores and tubular ducts absent. Trilocular pores somewhat sparse with 1–3 pores associated with the bases of the larger setae. Simple pores about a third of the size of the trilocular pores, sparsely but evenly distributed. Setae short and stout, almost lanceolate, longest seta on abdominal segments VI or VII 12–16 μm long.

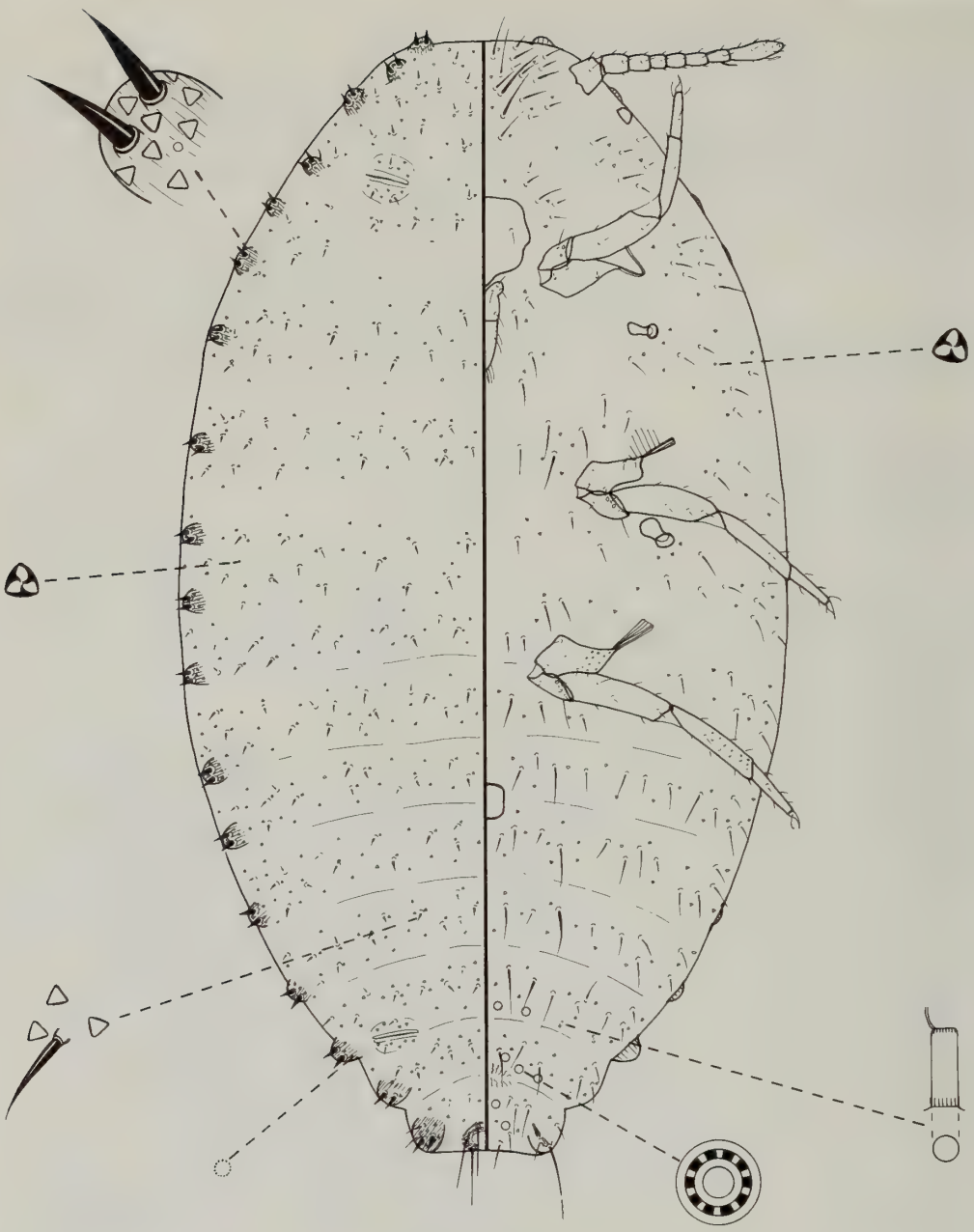

Fig. 4 *Planococcus boafoensis* (Strickland).

MATERIAL EXAMINED

12 ♀ (including type specimens listed below) (BMNH, MNNH).

Ghana (Gold Coast): 11 syntype ♀, Tafo, on *Musanga smithii*, 8.xi.1945 (*E. O. Boafo*) (BMNH).

DISTRIBUTION. Afrotropical Region: Ghana, Zaire.

HOSTPLANTS. Urticaceae: *Musanga cecropioides, M. smithii*.

REMARKS. This species is readily recognizable amongst the other known species of *Planococcus* by the sclerotised protuberances which bear the cerarii. Its relationships are difficult to determine, but it resembles the *dendrobii*-group in its distribution of multilocular disc pores and oral collar tubular ducts. *Cyperia angolia* De Lotto has very

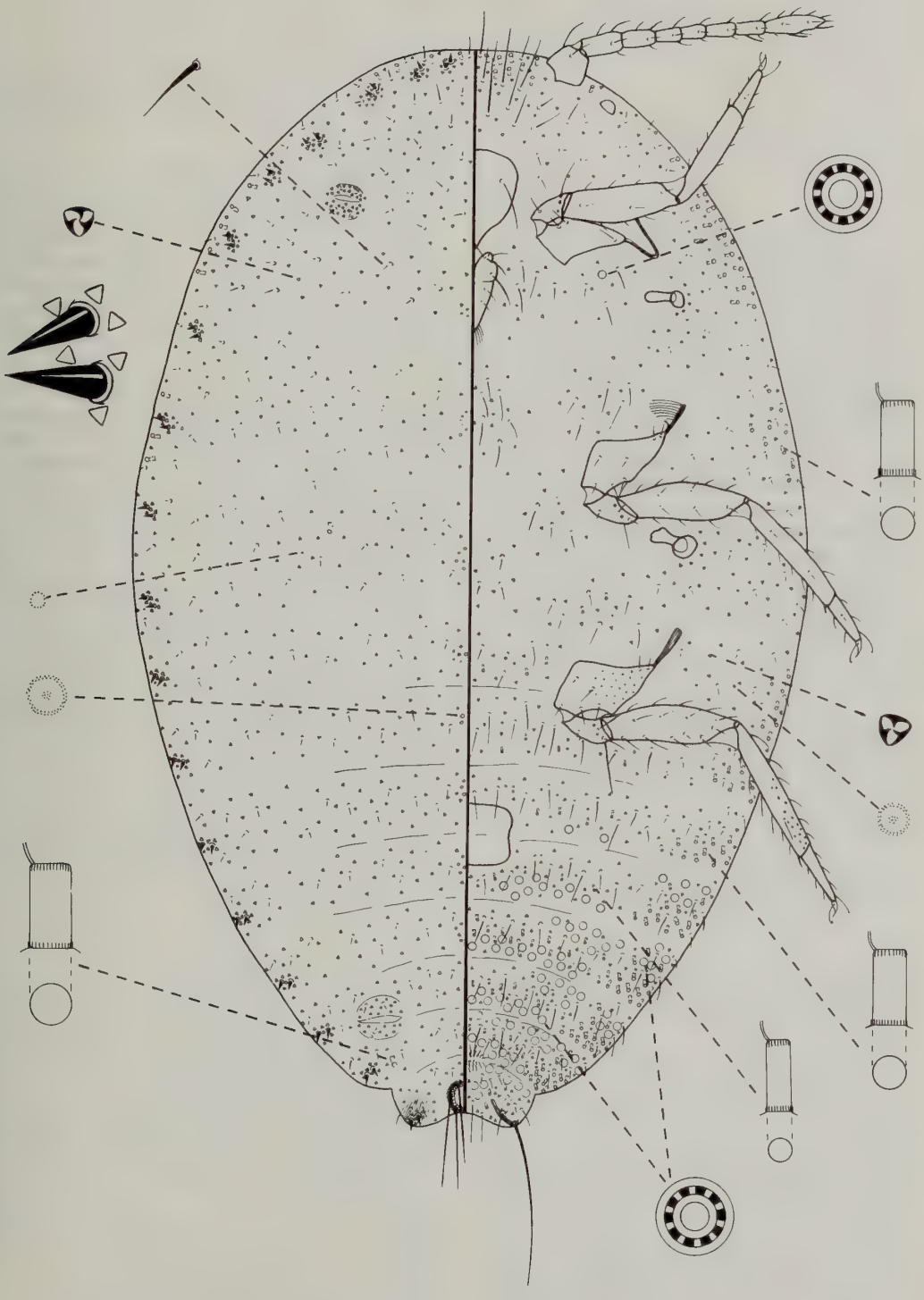

Fig. 5 *Planococcus citri* (Risso).

similar sclerotized protuberances, but differs in having flagellate auxiliary setae and more than 2 conical setae in most of the cerarii, and by having much longer dorsal setae than *Planococcus boafoensis*.

Planococcus citri (Risso)

(Fig. 5)

Dorthesia citri Risso, 1813: 416. Syntypes ♀, FRANCE: Menton, on *Citrus* sp. (probably lost).
Coccus citri (Risso) Boisduval, 1867: 348.
Dactylopius citri (Risso) Signoret, 1875: 312.
Lecanium phyllococcus Ashmead, 1879: 160. U.S.A.: Florida, on orange trees (status of type material not known). [Synonymy by Riley, 1888.]
Dactylopius destructor Comstock, 1881: 342. U.S.A.: Florida, on orange trees (status of type material not known). [Synonymy by Penzig, 1887.]
Phenacoccus spiriferus Hempel, 1900: 389. Syntypes ♀, BRAZIL: on cultivated tree (MZSP) [5 syntypes examined]. **Syn. n.**
Phenacoccus spiniferis Hempel; Hempel, 1901a: 110. [Misspelling.]
Pseudococcus citri (Risso) Fernald, 1903: 99.
Pseudococcus citri var. *phenacocciformis* Brain, 1915: 116. Syntypes ♀, SOUTH AFRICA: on *Bouvardia* sp. (SANC) [not examined]. [Synonymy by Ezzat & McConnell, 1956.]
Pseudococcus citri var. *coleorum* Marchal, 1908: 236. Syntypes ♀, FRANCE: on *Coleus* sp. (BMNH, MNNH) [4 syntypes examined]. [Synonymy by Borchsenius, 1949.]
Planococcus citri (Risso) Ferris, 1950: 165; Ezzat & McConnell, 1956: 65; Cox & Freeston, 1985: 722.
Planococcus citricus Ezzat & McConnell, 1956: 69. Holotype ♀, ITALY (intercepted in U.S.A.): on *Citrus limonia* (USNM) [examined]. [Synonymy by Cox, 1981.]
Planococcoides cubanensis Ezzat & McConnell, 1956: 55. Holotype ♀, CUBA (intercepted in U.S.A.): on *Ficus pandurate* (USNM) [examined]. **Syn. n.**
Planococcus cucurbitae Ezzat & McConnell, 1956: 71. Holotype ♀, GRENADA: on *Cucurbita* sp. (USNM) [examined]. **Syn. n.**

ADULT FEMALE. Mounted specimens oval, length 1.6–3.2 mm, width 1.0–2.0 mm. Margin of body with complete series of 18 pairs of cerarii, each cerarius with 2 conical setae, except for preocular cerarii which may have 1 or 3 setae each. Legs elongate; hind trochanter + femur 220–350 μm long, hind tibia + tarsus 260–420 μm long, ratio of lengths of hind tibia + tarsus to hind trochanter + femur 1.1–1.3; translucent pores apparent on hind coxae and tibiae. Inner edges of ostioles moderately sclerotized. Circulus quadrate, width 120–200 μm. Cisanal setae shorter than anal ring setae. Anal lobe cerarii each situated on a small, moderately sclerotized area.

Venter. Multilocular disc pores present around vulva, in single or double rows across posterior edges of abdominal segments III-VII, in single rows across anterior edges of segments V-VII, in marginal groups on abdominal segments IV-VII and sometimes a few pores scattered over median area of the thorax and head, but no more than a total of 6 pores behind the front coxae. Trilocular pores moderately numerous and evenly distributed. Oral collar tubular ducts of 2 sizes; smaller ducts present sparsely in rows across median areas of abdominal segments I-VII; larger ducts in marginal groups of variable size around entire venter including head and thorax, and scattered over median area of thorax. Simple pores about the same size as the trilocular pores, sparsely but evenly distributed.

Dorsum. Multilocular disc pores absent. Tubular ducts without apparent rims and slightly larger than the larger ducts on the venter, often present adjacent to some cerarii, 1 or 2 ducts sometimes present on median areas. Trilocular pores as for venter. Simple pores of 2 sizes, smaller pores smaller than the smaller size on the venter, scattered over entire dorsum, larger pores about twice the size of the trilocular pores, present in small groups along mid-line of thoracic and anterior abdominal segments. Setae flagellate and of moderate length, longest seta on abdominal segments VI or VII 30–35 μm long.

MATERIAL EXAMINED.
Several hundred field-collected adult females from many countries and host-plants in addition to the reared material used by Cox (1983) (BMNH, MNHN, USNM, VCI).
Planococcus spiriferus Hempel. 5 syntype ♀, on one slide labelled 'Phenacoccus spiniferus n. sp. Type ♀ 336'. The original description gives the habitat as Sao Paulo, in the grooves of leaves of a cultivated tree.
Planococcus citricus Ezzat & McConnell. Holotype ♀, **Italy** (intercepted at New York, Hidalgo): on *Citrus limonia*, 20.vii.1948 (USNM).
Planococcoides cubanensis Ezzat & McConnell. Holotype ♀, **Cuba** (intercepted at Hoboken, New Jersey): on *Ficus pandurate*, 11.vi.1948 (*Bennatt*) (USNM).

Planococcus cucurbitae Ezzat & McConnell. Holotype ♀, **Grenada**: on *Cucurbita* sp., 2.i.1944 (*R. G. Fennah*) (USNM).

DISTRIBUTION. Almost worldwide, but apparently absent from some South Pacific Islands and from the Malagasian Region.

HOSTPLANTS. Although *P. citri* is generally regarded as being polyphagous, which is indeed the case in greenhouses, in the field it is noticeably absent from certain host-plants. Thus De Lotto (1975) recorded that *P. citri*, although common on citrus in South Africa, was never found on grapevines. The mealybug found on vines throughout the Mediterranean basin is *P. ficus* and not *P. citri*.

REMARKS. Although there is no extant type material of *P. citri*, the identity of this species is not in question. Risso's original illustration of the live insect clearly shows it to be *Planococcus*, and the only species of this genus found on *Citrus* spp. in the Mediterranean Basin is *P. citri*. In fact, this species is well fitted to both its specific name 'citri and its common name, 'citrus mealybug', in that it shows a decided preference for this host throughout its geographical range.

Other species of *Planococcus* have been misidentified as *P. citri*. The very similar *P. minor* was only differentiated by rearing experiments studying the variation of both species (see Introduction) but is now known to be the predominant species in the South Pacific Islands, the Austro-oriental Region, the Malagasian Region and the northern Neotropical Region (Cox, 1981; Williams, 1982; Cox & Freeston, 1985). At one time *P. kenyae* was misidentified as *P. citri* and parasites sought in California for its control on coffee in Kenya (see under Remarks for this species). For a long time the distinction between *P. citri* and *P. ficus* was unclear, but the separation of these two species is now universally accepted (Ezzat & McConnell, 1956; De Lotto, 1975; Danzig, 1977; Cox, 1981).

P. citricus was considered by Ezzat & McConnell (1956) to differ from *P. citri* by having smaller appendages and fewer pores and ducts. Cox (1983) showed that these characteristics could be readily induced in *P. citri* by rearing specimens at high temperatures.

The syntypes examined of *Phenacoccus spiriferus* have numerous tubular ducts on the margins of the head and the thoracic segments, and are clearly *P. citri*. In the original description, the antennae are stated as being 9-segmented, but those of the syntypes are 8-segmented, with a slight pseudo-articulation indicated on the eighth segment – the measurements of the antennal segments given by Hempel show the eighth segment to comprise his eighth and ninth segments

Planococcoides cubanensis was described from a single specimen by Ezzat & McConnell (1956). It differs from normal *Planococcus citri* only by having three conical setae in each anal lobe cerarius. As no other similar specimens have been observed, and as *Planococcus* is apparently not native to the New World, this individual is here considered to be an aberrant specimen of *P. citri*.

P. curcurbitae was described from a single specimen by Ezzat & McConnell (1956). This specimen is heavily parasitized, and its main distinction from *P. citri* is that its anal ring setae are only about as long as the diameter of the anal ring. This characteristic has not been observed in any other specimen of *Planococcus* and is considered here to be an aberration. By the criteria given in Table 1, this specimen has been identified as *P. citri*, rather than *P. minor*, which it also resembles.

Morrison (1925) synonymized *Dactylopius calceolariae* var. *minor* with *Planococcus citri*. However, examination of the type material of this species has revealed that it is conspecific with a subsequently described species, *P. pacificus* Cox. No specimens of *P. citri* from the Malagasian Region have been observed during the course of this study.

ECONOMIC STATUS. *P. citri* is a serious pest of citrus in most citrus-growing areas of the world and is a major greenhouse pest in cooler regions.

Planococcus dendrobii Ezzat & McConnell

(Fig. 6)

Planococcus dendrobii Ezzat & McConnell, 1956: 73. Holotype ♀, INDIA (intercepted at Honolulu): on *Dendrobium transparens* (USNM) [not examined].

ADULT FEMALE. Mounted specimens rotund, length 1.7–2.6 mm, width 1.2–2.0 mm. Margin of body with a complete series of 18 pairs of cerarii, each with 2 stout conical setae. Legs stout; hind trochanter + femur 235–280 μm long, hind tibia + tarsus 220–250 μm long, ratio of lengths of hind tibia + tarsus to hind trochanter + femur 0.88–0.94; translucent pores apparent on hind coxae only. Inner edges of ostioles moderately strongly sclerotized. Circulus small and oval, width 75–115 μm. Cisanal setae shorter than anal lobe setae. Anal lobes not sclerotized.

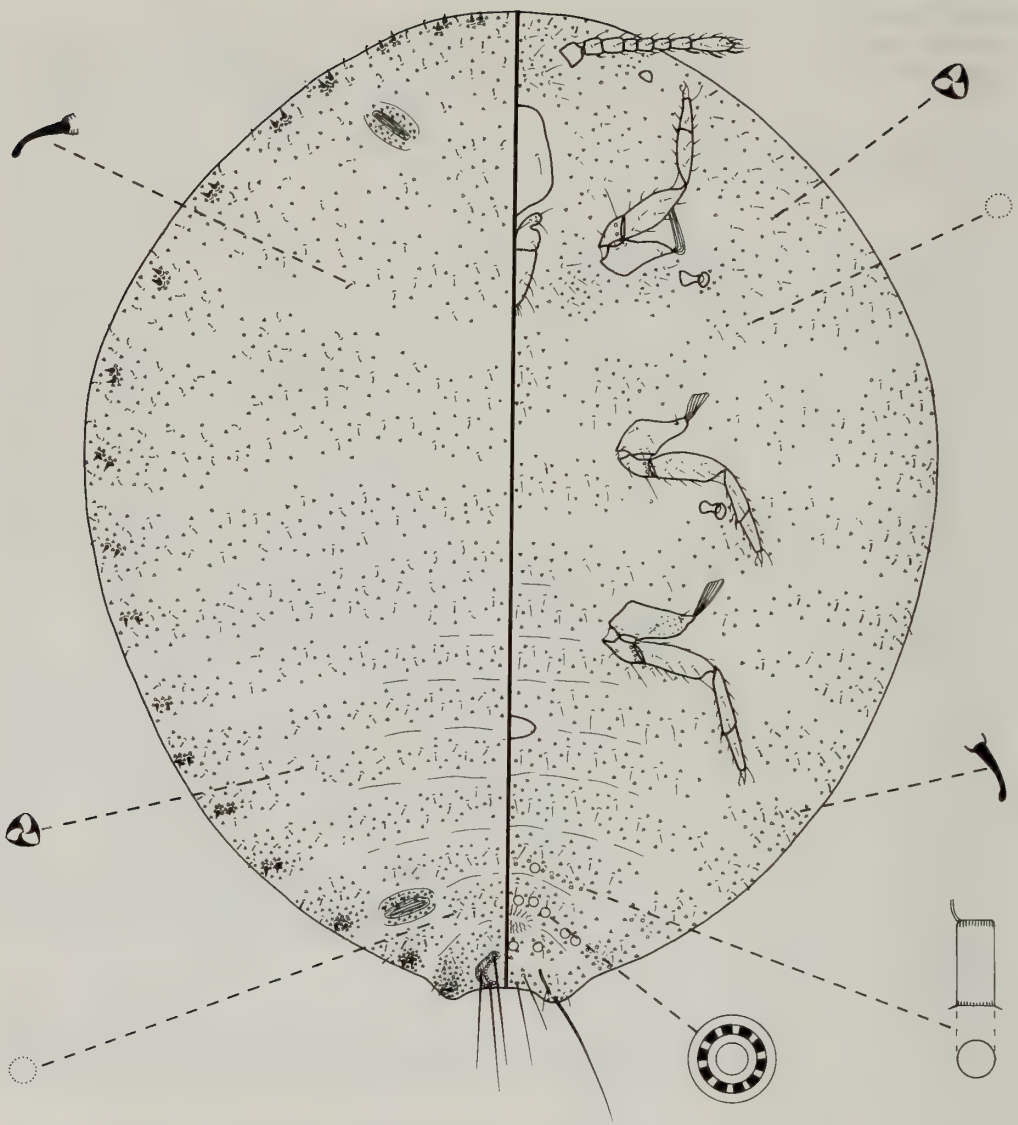

Fig. 6 *Planococcus dendrobii* Ezzat & McConnell.

Venter. Multilocular disc pores confined to median areas, present around vulva and in a single row across posterior edge of median area of abdominal segment VI. Trilocular pores numerous and evenly distributed. Oral collar tubular ducts of 1 size, confined to abdomen, present sparsely around vulva, a few ducts sometimes present on median area of segment V and in marginal groups on segments VI & VII. Simple pores slightly smaller than the trilocular pores, sparsely scattered over entire venter. Setae flagellate and moderately short on median areas, stout and knobbed on margins.

Dorsum. Multilocular disc pores and tubular ducts absent. Trilocular pores as for venter. Simple pores generally as for venter, but more numerous on median areas of posterior abdominal segments. Setae short, stout and distinctly knobbed, length of longest seta on abdominal segments VI or VII 13–15 μm.

MATERIAL EXAMINED

10 ♀ (including type material listed below) (BMNH, USNM).

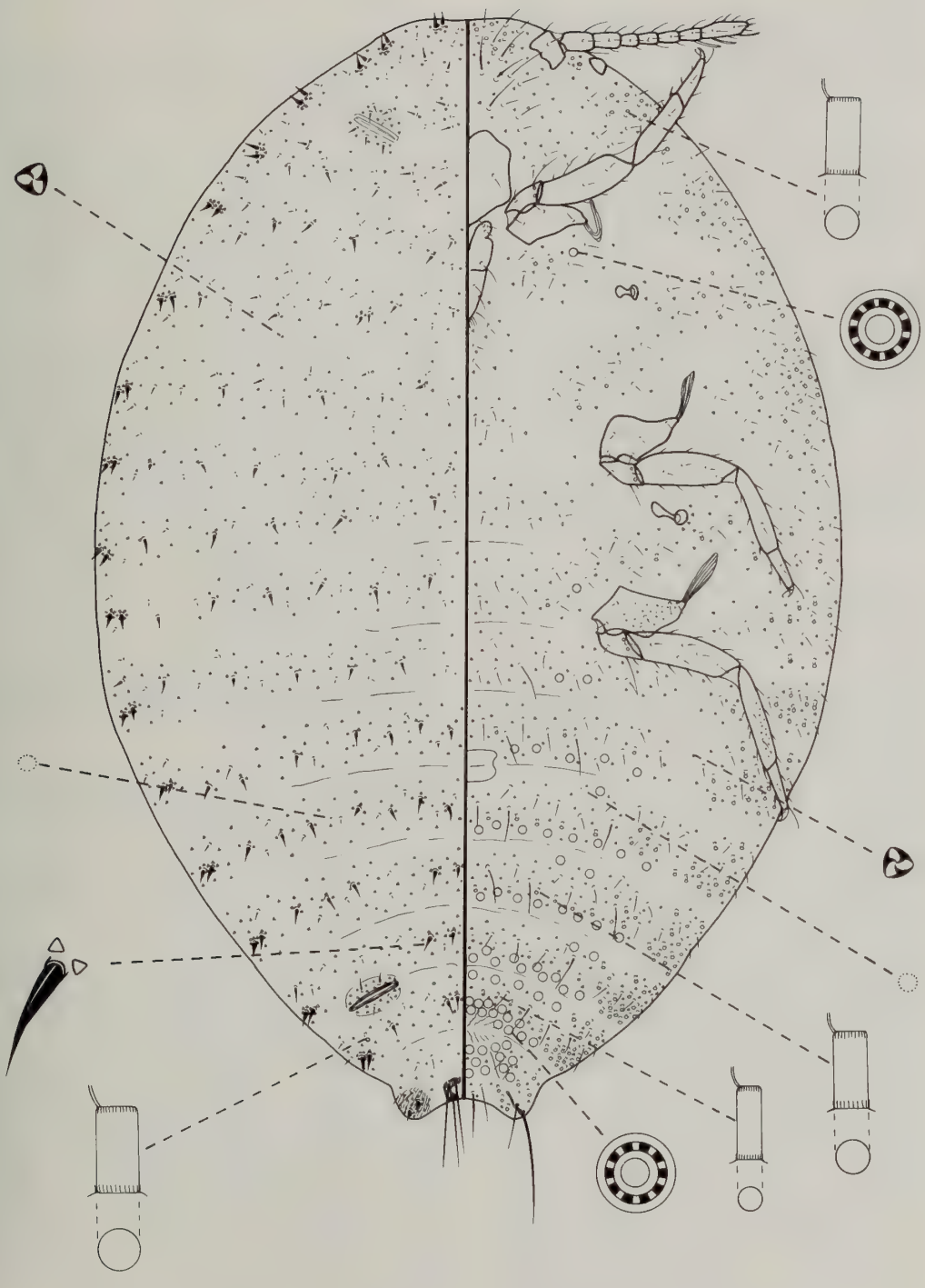

Fig. 7 *Planococcus dioscoreae* Williams.

India (intercepted at Honolulu): 2 paratype ♀, on *Dendrobium moschatum*, 16.iv.1947 (*S. Namiki*) (USNM).

DISTRIBUTION. Oriental Region: Bhutan (intercepted at Edinburgh), India (intercepted at Honolulu). Also recorded from the Philippines and Thailand (Ezzat & McConnell, 1956).

HOSTPLANTS. Orchidaceae: *Dendrobium moschatum*. Also recorded from *D. fimbriatum*, *D. transparens* and *Cypripedium* sp. (all Orchidaceae) (Ezzat & McConnell, 1956).

REMARKS. This species is very similar to *P. philippinensis*, having reduced numbers of multilocular disc pores and tubular ducts, dorsal setae knobbed and translucent pores absent from hind tibiae. The two species may be distinguished by the presence of a circulus in *P. dendrobii* and by the smaller simple pores on the dorsum of the posterior abdominal segments in this species. See also under *P. hospitus* for further remarks.

ECONOMIC STATUS. This species is a potential pest of orchids.

Planococcus dioscoreae Williams

(Fig. 7)

Planococcus dioscoreae Williams, 1960: 39. Holotype ♀, PAPUA NEW GUINEA: on yam (BMNH) [examined].

ADULT FEMALE. Mounted specimens oval to broadly oval, length 2.0–2.5 mm, width 1.2–2.0 mm. Margin of body with a complete series of 18 distinct pairs of cerarii, each cerarius with 2 conical setae except for the preocular cerarii with 2 or 3 setae, all cerarian setae elongate-conical and with flagellate tips. Legs elongate, hind trochanter + femur 220–285 μm long, hind tibia + tarsus 235–285 μm long; ratio of lengths of hind tibia + tarsus to hind trochanter + femur 1.00–1.08; translucent pores visible on hind coxae and tibiae. Inner edges of ostioles lightly sclerotized. Circulus quadrate and of moderate size, width 65–170 μm. Cisanal setae shorter than anal ring setae. Anal lobe cerarii each situated on a small, moderately sclerotised area.

Venter. Multilocular disc pores confined to median areas, present around vulva, in single rows across posterior borders of abdominal segments II-VII and anterior borders (sometimes reduced to 1 or 2 pores per segment in small specimens) of abdominal segments III-VII or IV-VII, and a few spores scattered over median areas of thorax. Trilocular pores sparsely but evenly distributed. Oral collar tubular ducts of 2 sizes; smaller ducts present in rows across median areas of abdominal segments VI or VII; larger ducts present in rows across abdominal segments III-V, scattered over median areas of thorax, and present in groups around entire venter, including a group adjacent to each postocular cerarius. Simple pores about half the size of the trilocular pores, sparsely scattered over entire venter.

Dorsum. Multilocular disc pores absent. Trilocular pores moderately numerous and aggregated around bases of enlarged setae. Tubular ducts, larger than the larger ducts on the venter and without apparent rims, sometimes present singly next to some abdominal cerarii, no more than 2 present on any specimen and frequently absent. Simple pores as for venter. Dorsal setae of various sizes, larger setae elongate-conical with a flagellate apex, about the same size as the cerarian setae and each with 2–4 trilocular pores associated with their bases giving the appearance of dorsal cerarii, these enlarged setae present on all segments except the last and usually solitary with no more than 4 pairs present.

MATERIAL EXAMINED

53 ♀ (including type material listed below) (all BMNH).

Holotype ♀, **Papua New Guinea**: Sepik District, Bunahoj, on yams, 22.vi.1959 (*J. J. H. Szent-Ivany*). Paratypes, 32 ♀, same data except various villages, 22.v.-23.vi.1959.

DISTRIBUTION. Austro-oriental Region: Papua New Guinea, Solomon Islands.

HOSTPLANTS. Dioscoreaceae: *Dioscorea* sp. (yams), *D. alata*. Araceae: *Xanthosoma sagittifolium*.

REMARKS. The enlarged dorsal setae with associated aggregations of trilocular pores place this species in the *dorsospinosus*-group. It differs from both of the other two species in this group, *P. dorsospinosus* and *P. litchi*, by having 3–10 ventral tubular ducts adjacent to each post-ocular cerarius; from *P. dorsospinosus* by having larger and more flagellate dorsal setae; and from *P. litchi* by having the dorsal setae associated into no more than 4 pairs. *P. dioscoreae* is particularly close to *P. dorsospinosus*, and the specimens from India on yams listed under the latter species are somewhat intermediate in their characteristics. The whole group needs further study to clarify the relationship between these two species.

ECONOMIC STATUS. This species has been found heavily infesting yams.

Planococcus dorsospinosus Ezzat & McConnell

(Fig. 8)

Planococcus dorsospinosus Ezzat & McConnell, 1956: 75. Holotype ♀, China (intercepted in U.S.A.): on *Pueraria hirsuta* (USNM) [examined].

Planococcus myrsinephilus Borchsenius, 1962: 585. Holotype ♀, China: on *Myrsine africana* (ZIL) [not examined]. **Syn. n.**

Planococcus sinensis Borchsenius, 1962: 586. Holotype ♀, China: on *Buddleia officinalis* (ZIL) [not examined]. **Syn. n.**

Adult female. Mounted specimens oval, length 2.4–3.5 mm, width 1.3–2.1 mm. Margin of body with a complete series of 18 distinct pairs of cerarii, each cerarius with 2 conical setae except for the preocular cerarii each with 3 or 4 setae, all cerarian setae conical and with slightly flagellate tips. Legs elongate, hind trochanter + femur 245–370 μm long, hind tibia + tarsus 255–400 μm long; ratio of lengths of hind tibia + tarsus to hind trochanter + femur 0.97–1.12; translucent pores visible on hind coxae and tibiae. Inner edges of ostioles lightly sclerotized. Circulus quadrate and of moderate size, width 85–130 μm. Cisanal setae shorter than anal ring setae. Anal lobe cerarii each situated on a moderately sized, well-sclerotized area.

Venter. Multilocular disc pores usually confined to median areas, rarely 1 or 2 pores present on margins of 1 or 2 posterior abdominal segments; present around vulva, in single or double rows across posterior edges of abdominal segments III-VI (sometimes also 1 or 2 pores also on segment II) and anterior edge of abdominal segment VI or VII (sometimes 1 or 2 pores also present on anterior border of segment V), and a variable number of pores scattered over thorax. Trilocular pores sparsely but evenly distributed. Oral collar tubular ducts of 2 sizes; smaller ducts in rows across median areas of abdominal segments VI or VII; larger ducts in rows across abdominal segments III-VII, scattered over median areas of thorax and in marginal groups on all head, thoracic and abdominal segments; up to 4 ducts sometimes present adjacent to each postocular cerarius. Simple pores about half the size of the trilocular pores, sparsely scattered over entire venter.

Dorsum. Multilocular disc pores absent. Trilocular pores moderately numerous and aggregated around bases of enlarged setae. Tubular ducts, considerably larger than the larger ducts on the venter and without apparent rims, sometimes present singly next to some abdominal cerarii. Simple pores as for venter but very sparse. Dorsal setae of various sizes, conical and without flagellate apices, larger setae slightly smaller than the cerarian setae and each with 1–3 trilocular pores associated with their bases giving the appearance of dorsal cerarii; these enlarged setae present on all body segments except the last abdominal segment, generally occurring singly, but sometimes up to 4 pairs present, length of longest conical seta on abdominal segments VI or VII 15–20 μm.

Material examined

21 ♀ (including type material listed below (BMNH, USNM, ZIL).

Planococcus dorsospinosus Ezzat & McConnell. Holotype ♀, **China** (intercepted at San Francisco, U.S.A.): on *Pueraria hirsuta* (kudzu vine), 20.i.1947 (*F. L. Blane*); 1 paratype ♀, same locality, on *Colocasia esculentum*, 10.i.1947 (*F. M. Thompson*) (both USNM).

Planococcus myrsinephilus Borchsenius. 1 paratype ♀, **China**: Yunnan Province, near Siakwan, on leaves and small branches of *Myrsine africana*, 18.iv.1957 (*N. Borchsenius*) (ZIL).

Planococcus sinensis Borchsenius. 1 paratype ♀, **China**: Yunnan Province, near Siakwan, 17.iv.1957 (*N. Borchsenius*) (ZIL).

Distribution. Palaearctic Region: Japan (intercepted in U.S.A.). Oriental Region: China, Hongkong, India, Taiwan (intercepted in U.S.A.), Thailand (intercepted in U.S.A.). Austro-oriental Region: Philippines (intercepted in U.S.A.).

Hostplants. Aceraceae: *Acer* sp. (branches). Araceae: *Colocasia esculentum*. Dioscoreaceae: *Dioscorea* sp. (root). Euphorbiaceae: *Euphorbia longan*. Leguminosae: *Pueraria hirsuta*. Meliaceae: *Lansium domesticum* (fruit). Myrsinaceae: *Myrsine africana* (leaves and small branches). Myrtaceae: *Eugenia* sp. (fruit), *Psidium guajava*. Punicaceae: *Punica granatum* (fruit). Rubiaceae: *Coffea canephora* (roots). Also recorded from *Litchi* sp. (Sapindaceae) by Ezzat & McConnell (1956) and as *P. sinensis* on the leaves, branches and stems of *Ficus gibbosa*, *Morus* sp. (Moraceae), *Buddleia officinalis* (Buddleiaceae), *Rhus* sp. (Anacardaceae) and *Daphniphyllum* sp. (Daphniphyllaceae) by Borchsenius (1962).

Remarks. This species is very similar to *P. dioscoreae*, apparently differing only in having relatively smaller and stouter enlarged dorsal setae and by having no more than 4 tubular ducts

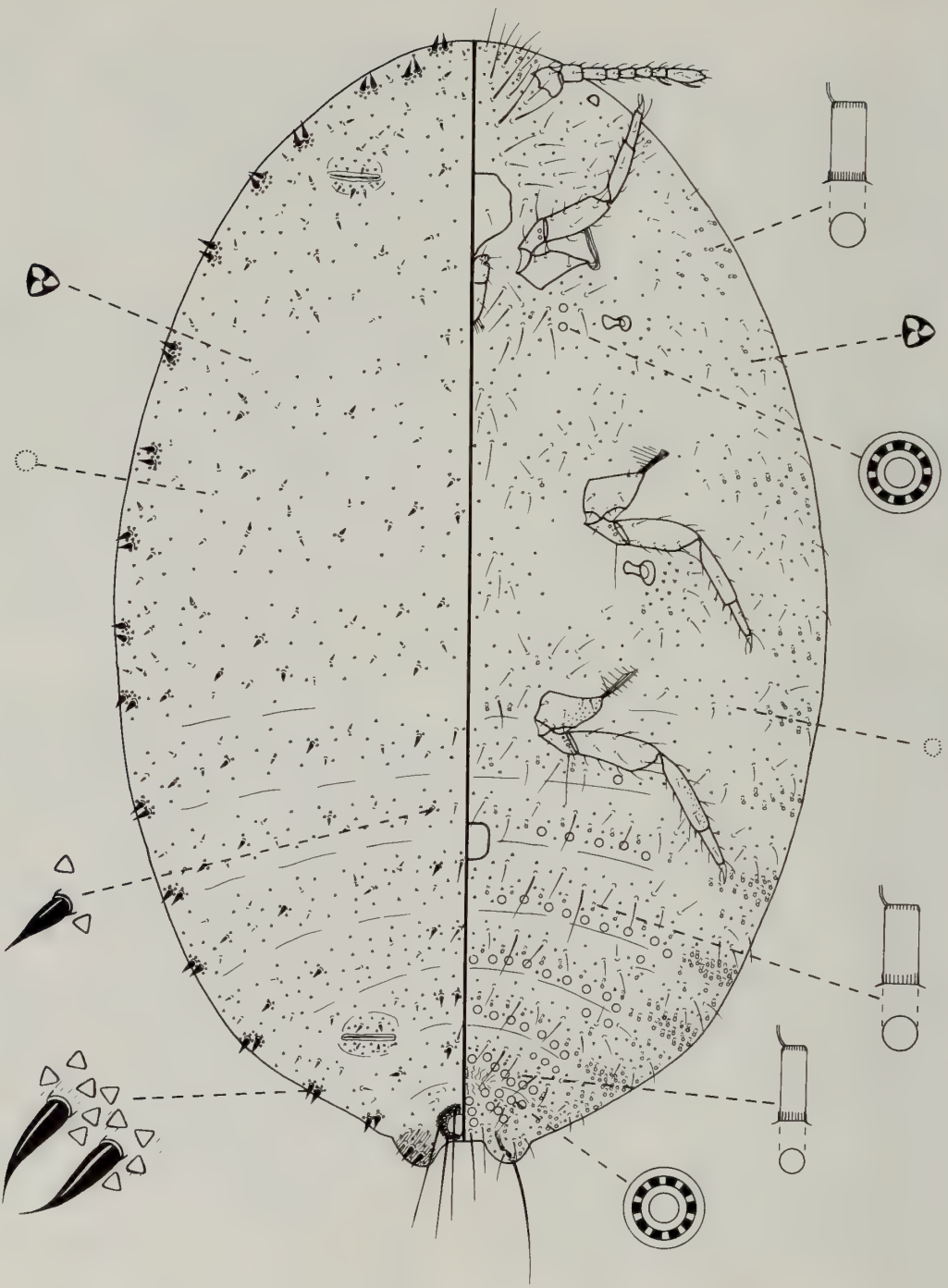

Fig. 8 *Planococcus dorsospinosus* Ezzat & McConnell.

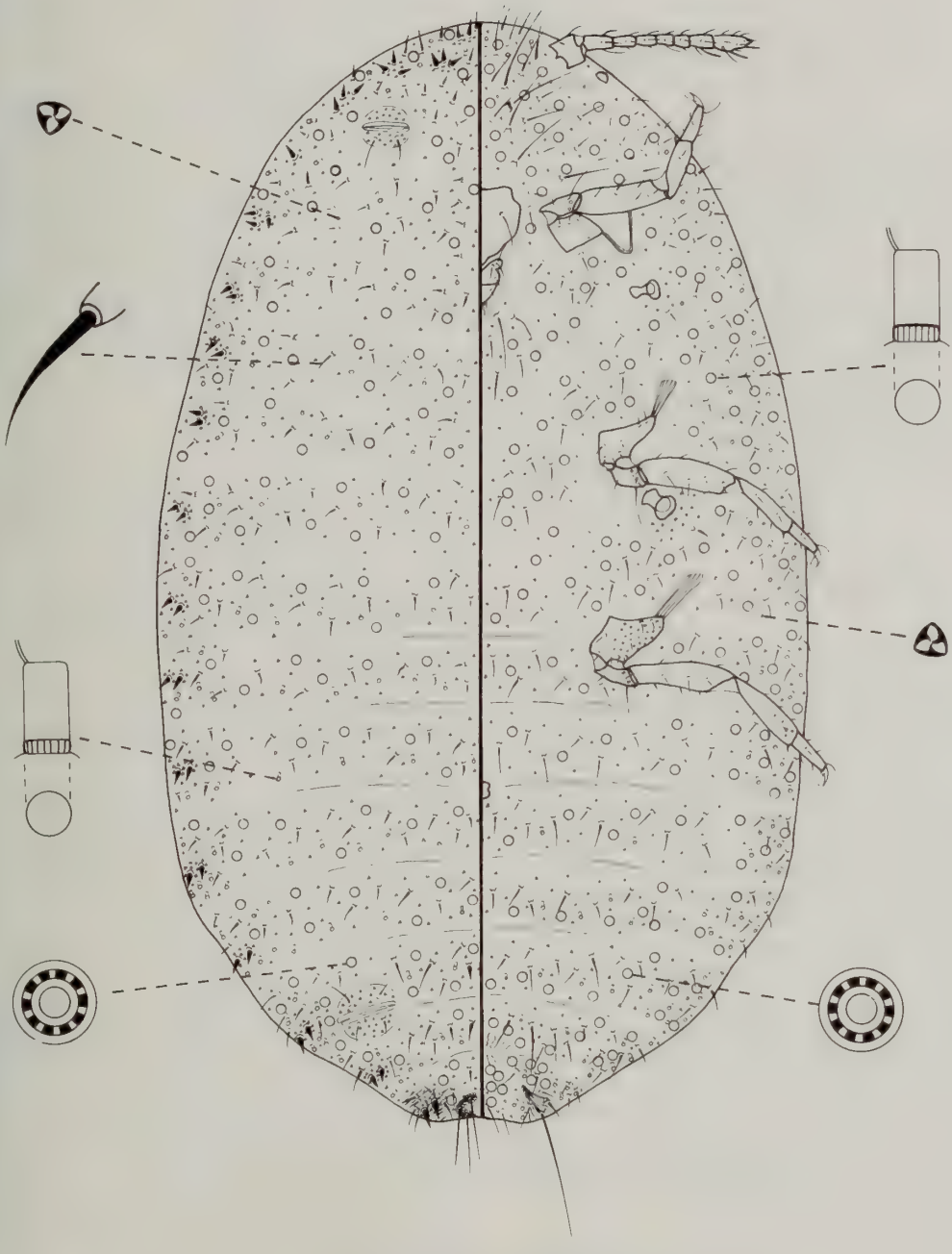

Fig. 9 *Planococcus dubius* Cox.

adjacent to each preocular cerarius. The specimens from *Dioscorea* and *Coffea robusta* roots listed above constitute the records from India. These specimens are somewhat intermediate in appearance between *P. dorsospinosus* and *P. dioscoreae* – more material from a wide area will be necessary to completely resolve this complex. Both of these species may be distinguished from *P. litchi* by having the enlarged dorsal setae associated into no more than 4 pairs. *P. dorsospinosus* appears to be somewhat variable, with larger specimens having wider bands of multilocular disc pores across the abdominal segments and more of these pores on the thorax. The apparent length of the dorsal setae is somewhat dependent on the preparation of the specimens onto microscope slides, as the flagellate tips are easily broken off. Borchsenius (1962) separated *P. sinensis* from *P. dorsospinosus* and *P. dioscoreae* by the lack of sclerotization of the anal lobes in the latter 2 species, but this character is also very dependent on the microscopic preparation

Economic status. This species is frequently intercepted on produce in the U.S.A.

Planococcus dubius Cox

(Fig. 9)

Planococcus dubius Cox, 1987: 75. Holotype o, NEW ZEALAND: on *Dracophyllum latifolium* (NZAC) [examined].

Adult female. Mounted specimens oval, length 2.4–3.2 mm, width 1.5–1.8 mm. Margin of body seldom with a complete series of 18 pairs of cerarii, 12–18 pairs, each cerarius with 1–4 conical setae on head and thorax, and 1 or 2 conical setae on the abdomen, occasionally a single flagellate auxiliary seta associated with one abdominal cerarius. Legs elongate; hind trochanter + femur 320–390 μm long, hind tibia + tarsus 310–360 μm long, ratio of lengths of hind tibia + tarsus to hind trochanter + femur 0.93–1.00; translucent pores apparent on hind coxae and tibiae. Inner edges of ostioles moderately sclerotized. Circulus, if apparent, small and quadrate, width 40–50 μm. Cisanal setae shorter than anal ring setae. Anal lobe cerarii each situated on a moderately sized, well-sclerotised area.

Venter. Multilocular disc pores present around vulva, in single rows across posterior edges of median areas of abdominal segments V or VI, a few present on anterior edges of median areas of segments V-VII, and scattered over head, thorax and margins of entire body. Trilocular pores moderately numerous and evenly distributed. Oral collar tubular ducts of 2 sizes, smaller ducts present sparsely in rows across median areas of abdominal segments IV-VII, larger ducts moderately numerous around margins of entire venter. Simple pores about half the size of the trilocular pores, sparsely scattered over entire venter. Setae somewhat long and stout.

Dorsum. Multilocular disc pores numerous over entire surface. Tubular ducts, the same size as the larger ducts on the venter and without aparent rims, sparse to moderately numerous over entire dorsum, forming rows across most body segments. Trilocular pores as for venter. Simple pores about a quarter of the size of the trilocular pores, sparsely scattered over entire dorsum. Setae generally long and with enlarged bases but almost conical on median areas of abdominal segments VI or VII, length of longest of these setae 23–30 μm.

Material examined

10 ♀ (including type material listed) (BMNH, NZAC).

Holotype ♀, **New Zealand**: Auckland, Waitakere Range, on *Dracophyllum latifolium*, 16.xi.1973 (*J.A. de Boer*) (NZAC). Paratypes, 2 ♀, same data as holotype (BMNH, NZAC); 1 ♀, **New Zealand**: Lake Waikaremoana, at base of leaves of *Dracophyllum* sp., 4.iii.1983 (*J. M. Cox*) (BMNH, NZAC).

Distribution. New Zealand only.

Hostplants. Epacridaceae: *Dracophyllum* sp., *D. latifolium*.

Remarks. *P. dubius* was placed in *Planococcus* by Cox (1987), despite usually having fewer than 18 pairs of cerarii, because most specimens have three pairs of cerarii anterior to the eyes and, taken as a group, the type specimens show cerarii in all the 18 possible positions on the body.

This species is very variable in its numbers of cerarii and multilocular disc pores. Moreover, the non-type material examined, collected in a different part of New Zealand from the type material, apparently lack circuli – these specimens may prove to be a different species when more material has been collected and examined.

The affinities of this species with other members of *Planococcus* are difficult to determine. The presence of flagellate auxiliary setae in one abdominal cerarius in some specimens suggests that this species may actually be closer to *Planococcoides* than to *Planococcus*. The only other species of *Planococcus* with dorsal multilocular disc pores is the African *P. epulus*, but the latter species has more flagellate dorsal setae on

abdominal segments VI VII and each cerarius is distinct and with 2 conical setae. *P. dubius* may be most closely related to the other species of *Planococcus* found in New Zealand, *P. mali* (although this species is suspected here of originating in Japan), as some cerarii are indistinct, the dorsal setae are stout and some of the cephalic and thoracic cerarii have more than 2 conical setae. However, it is also close to the New Zealand species placed by Cox (1987) in *Paracoccus*, all of which have oral rim tubular ducts and, except for *P. zealandicus* (Ezzat & McConnell), substantially fewer than 18 pairs of cerarii. The presence of oral rim tubular ducts does not, in itself, exclude *P. zealandicus* from *Planococcus*, but it was placed in *Paracoccus* by Cox (1987), despite sometimes having 18 pairs of cerarii, as it is clearly congeneric with some of the other New Zealand species placed in *Paracoccus* such as *P. drimydis* (Brittin) and *P. glaucus* (Maskell). Eventually, when the generic concepts of mealybugs are better understood, these New Zealand species may require the erection of a new genus.

Planococcus epulus De Lotto

(Fig. 10)

Planococcus epulus De Lotto, 1964: 375. Holotype ♀ KENYA: on *Pterolobium lacerans* (BMNH) [examined].

ADULT FEMALE. Mounted specimen elongate-oval, length 1.7 mm, width 1.1 mm. Margin of body with complete series of 18 pairs of cerarii, each cerarius with 2 (rarely 1 on thorax) moderately stout conical setae. Legs elongate; hind trochanter + femur 315 μm long, hind tibia + tarsus 350 μm long, ratio of lengths of hind tibia + tarsus to hind trochanter + femur 1.11; translucent pores present on hind tibiae but not apparent on hind coxae. Inner edges of ostioles not noticeably sclerotized. Circulus quadrate, width 145 μm. Cisanal setae shorter than anal ring setae. Anal lobe cerarii each situated on a small, moderately sclerotised area.

Venter. Multilocular disc pores moderately numerous around vulva, present in rows across anterior and posterior edges of abdominal segments II-VII, in small marginal groups on segments III-VII and scattered over median areas of venter. Trilocular pores moderately numerous and evenly distributed. Oral collar tubular ducts of 2 sizes; smaller ducts present sparsely in rows across median areas of abdominal segments VI or VII; larger ducts sparsely scattered over median areas of head and thorax, present in rows across median areas of abdominal segments, and in marginal groups around entire venter. Simple pores minute, sparsely but evenly distributed.

Dorsum. Multilocular disc pores sparsely scattered over thorax and abdomen. Tubular ducts of same form and size as the larger ducts on the venter, moderately numerous over entire dorsum. Trilocular pores and simple pores as for venter. Setae long and flagellate, longest seta on abdominal segments VI or VII about 45 μm long.

MATERIAL EXAMINED

Known from holotype ♀ only, **Kenya:** Nairobi, 7.1.1957, on *Pterolobium lacerans* (*G. De Lotto*) (BMNH).

DISTRIBUTION. Afrotropical Region: Kenya.

HOSTPLANT. Leguminosae: *Pterolobium lacerans*.

REMARKS. The only other known species of *Planococcus* with dorsal multilocular disc pores is *P. dubius* from New Zealand (see under Remarks for this species). In all other characters, *P. epulus* appears to be a member of the *P. citri*-group.

Planococcus ficus (Signoret)

(Fig. 11)

[*Coccus vitis* L.; Nedzel'skii, 1869: 19. Misidentification.]

Dactylopius ficus Signoret, 1875: 315. Syntypes ♀, FRANCE: on edible fig (probably lost).

[*Dactylopius vitis*; Lichtenstein, 1870: L. Misidentification.]

Dactylopius subterraneus Hempel, 1901b: 388. Syntypes ♀, ARGENTINA: on roots of cultivated grapes (VCCB) [1 syntype examined by D. J. Williams]. **Syn. n.**

Pseudococcus ficus (Signoret) Fernald, 1903: 101.

Pseudococcus subterraneus (Hempel) Fernald, 1903: 110.

[Pseudococcus vitis (Niedielski) Fernald, 1903: 112. Misidentification.]

Pseudococcus citrioides Ferris, 1922: 203. Holotype ♀, LIBYA: on ? (UCD) [examined]. [Synonymized by Cox & Ben-Dov, 1986.]

Planococcus citrioides (Ferris) Ferris, 1950: 164.

Planococcus ficus (Signoret) Ezzat & McConnell, 1956: 79.

[*Planococcus vitis* (Niedielski) Ezzat & McConnell, 1956: 103. Misidentification.]

ADULT FEMALE. Mounted specimens oval, length 1.4–3.2 mm, width 0.8–2.2 mm. Margin of body with complete series of 18 pairs of cerarii, each cerarius with 2 conical setae, more slender towards the anterior of the body. Legs elongate; hind trochanter + femur 235–355 μm long, hind

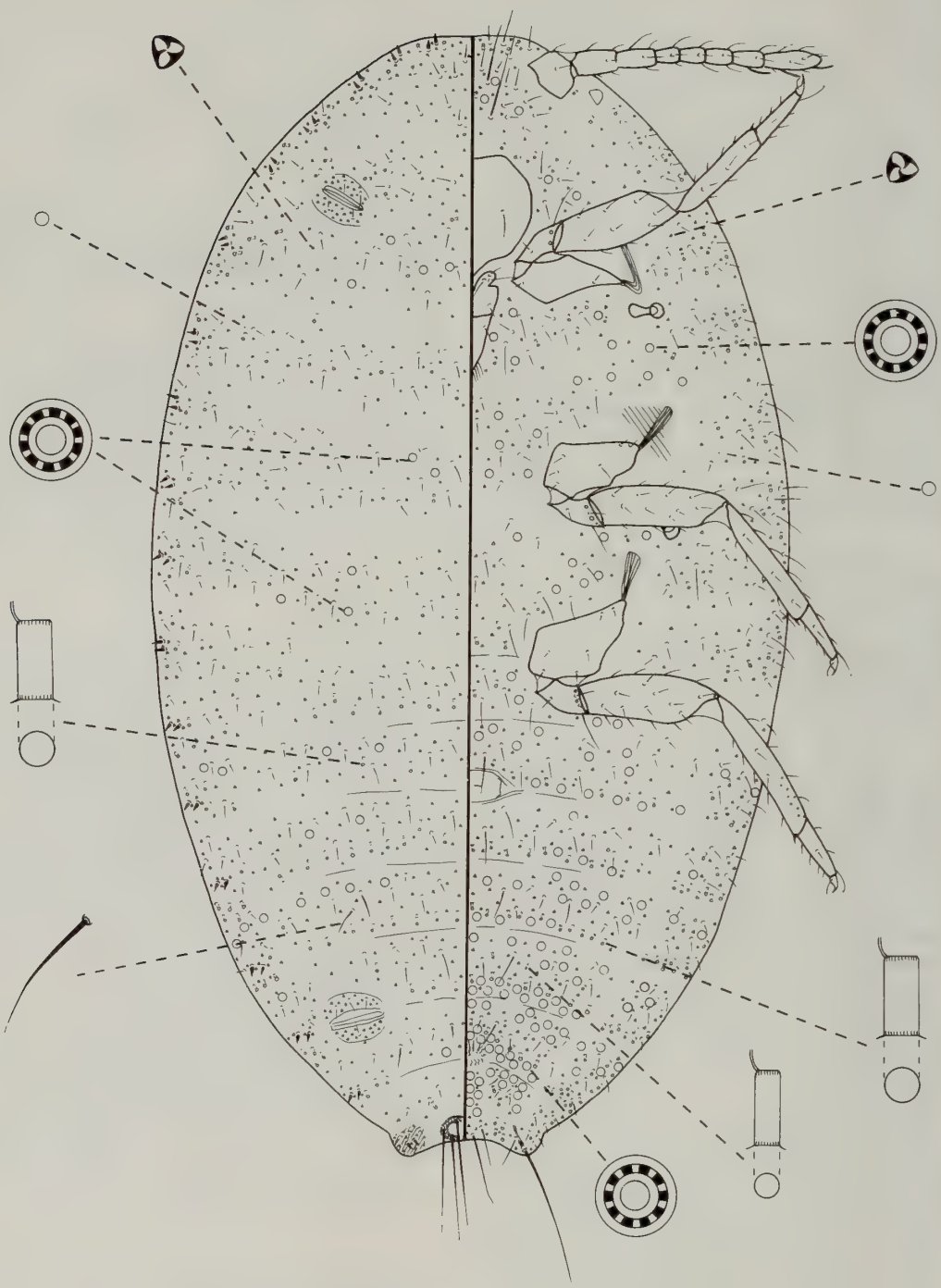

Fig. 10 *Planococcus epulus* De Lotto.

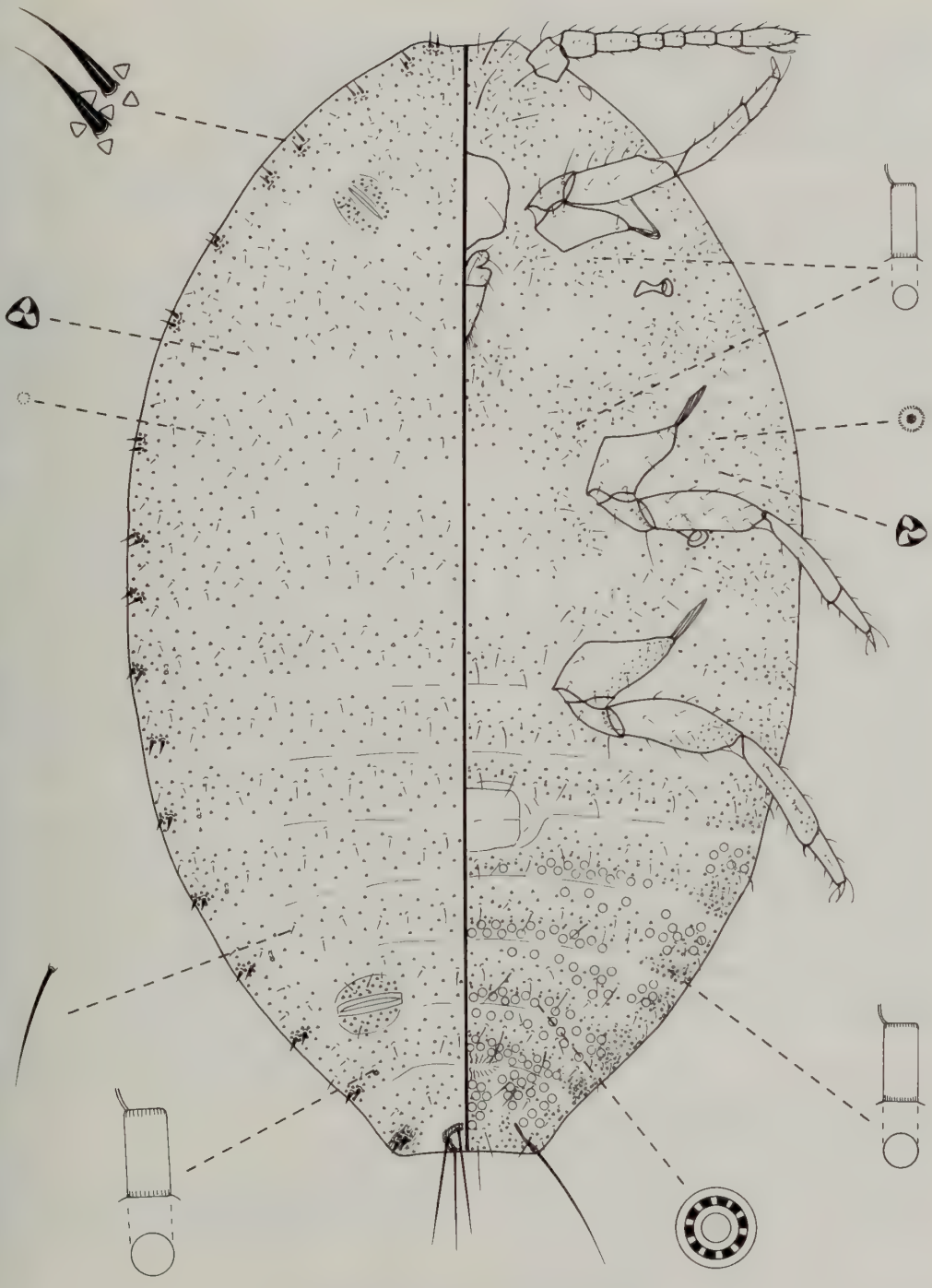

Fig. 11 *Planococcus ficus* (Signoret).

tibia + tarsus 275–395 μm long, ratio of lengths of hind tibia + tarsus to hind trochanter + femur 1.01–1.17; translucent pores apparent on hind coxae and tibiae, and often also on hind femora. Inner edges of ostioles moderately sclerotized. Circulus quadrate, width 115–150 μm. Cisanal setae shorter than anal ring setae. Anal lobe cerarii each situated on a small, moderately sclerotized area.

Venter. Multilocular disc pores present around vulva; in single rows across posterior edges of abdominal segments III-VII or II-VII and across anterior edges of segments V-VII; in marginal groups on posterior abdominal segments, usually as far forward as segment II; often present in groups of up to 12 pores behind each front coxa; and sparsely scattered over median areas of the thorax. Trilocular pores moderately numerous and evenly distributed. Oral collar tubular ducts of 2 sizes; smaller ducts present sparsely in rows across median areas of abdominal segments V-VII; larger ducts present sparsely in rows across median areas of abdominal segments II-VII, in marginal groups on segments II-VIII, scattered over median area of thorax, a single pore sometimes present on head, and up to 3 pores sometimes present on each margin of the thoracic segments. Simple pores slightly smaller to slightly larger than the trilocular pores, sparsely but evenly distributed.

Dorsum. Multilocular disc pores absent. Tubular ducts, larger than those on the venter and frequently with distinct rims, usually occurring singly (rarely in pairs) adjacent to some or most cerarii. Trilocular pores as for venter. Simple pores of two sizes; larger pores, if apparent, larger than the trilocular pores, present in groups of 1–3 pores on mid-line of some thoracic and abdominal segments; smaller pores minute, scattered sparsely over entire dorsum. Setae long and flagellate, longest seta on abdominal segment VI or VII 23–50 μm long.

Material examined

About 50 ♀ (including type material listed) (BMNH, MNNH, UCD, USNM, VCI).

Pseudococcus citrioides Ferris. Holotype ♀, **Libya**: Cyrenaica Guarsia, on ?, 4.iv.1922 (*F. Silvestri*) (UCD); 2 paratype ♀, same data as holotype (UCD).

Distribution. Palaearctic Region: Cyprus, Egypt, France, Greece, Iran, Iraq, Israel, Italy, Lebanon, Libya, Saudi Arabia, Spain, Tunisia, Turkey. Afrotropical Region: South Africa. Oriental Region: Pakistan. Neotropical Region: Argentina.

Hostplants. Anacardaceae: *Mangifera indica*. Lauraceae: *Persea americana*. Leguminosae: *Dichrostachys glomerata, Prosopis fareta, Tephrosia purpurea*. Moraceae: *Ficus carica*. Palmae: *Phoenix dactylifera*. Punicaceae: *Punica granatum*. Rhamnaceae: *Zizyphus spina-christi*. Rosaceae: *Malus pumila*. Salicaceae: *Salix* sp. Styraceae: *Styrax officinale*. Vitidaceae: *Vitis vinifera*. Most of the specimens examined were from grapevines or, less commonly, figs.

Remarks. *P. ficus* was frequently misidentified as *P. citri* before the works of Ezzat & McConnell (1956) and De Lotto (1975), and most records of *P. citri* from grapevines should be referred to *P. ficus*. As discussed in detail by De Lotto (1975) and Cox & Ben-Dov (1986), the binomen *Plancoccus vitis* is invalid, and records under this name should be referred to *P. ficus*.

P. ficus is very similar to *P. halli* from the Afrotropical Region and the West Indies, where it is frequently found on yams. The distinction of these two species is discussed under the Remarks on *P. halli*. One of the most distinctive characters of *P. ficus*, the presence of translucent pores on the hind femora, is not apparent in many specimens. Cox & Wetton (in press), who reared this species, found that its expression was dependent on temperature, translucent pores being present on the hind femora of most specimens reared at high temperatures, but absent from most specimens reared at low temperatures

Dr D. J. Williams, C.A.B. International Institute of Entomology, examined and sketched a syntype of *Dactylopius subterraneus* Hempel during a recent visit to Brazil, and concluded that it was *P. ficus*. According to his notes and sketch, the specimen has elongate conical setae in the cephalic cerarii and 5 and 8 multilocular disc pores behind the respective front coxae. The original description states that the female is gall-forming, but it is more likely that the mealybug was merely occupying a vacated gall formed by some other organism.

Economic status. *P. ficus* is the common mealybug on grapevines throughout the Mediterranean Basin and now also occurs on this host in Argentina, Pakistan and South Africa. It will probably continue to spread to other areas where grapevines are grown.

Rosen & DeBach (1977) noted that the parasite fauna supported by the vine mealybug in Israel is significantly different from that of the citrus mealybug.

Planococcus flagellatus De Lotto

(Fig. 12)

Planococcus flagellatus De Lotto, 1961: 220. Holotype ♀, UGANDA: on roots of *Vernonia auriculifera* (BMNH) [examined].

ADULT FEMALE. Mounted specimens oval, length 1.7–3.2 mm, width 1.2–2.2 mm. Margin of body with complete series of 18 pairs of cerarii, each cerarius with 2 slender, often very elongate, conical setae. Legs elongate; hind trochanter + femur 255–335 μm long, hind tibia + tarsus 285–370 μm long, ratio of lengths of hind tibia + tarsus to hind trochanter + femur 0.93–1.12; translucent pores apparent on hind coxae and tibiae. Inner edges of ostioles lightly sclerotized. Circulus variable in size, small and round to larger and quadrate, width 15–160 μm. Cisanal setae variable, from shorter than (including type series) to longer than, anal ring setae. Anal lobe cerarii situated on small, moderately sclerotized areas.

Venter. Multilocular disc pores present around vulva, in single or double rows across posterior edges of median areas of abdominal segments I-VII or II-VII (occasionally absent from segments I-III), usually a few present on anterior edges of segments III-VII, present in small groups on margins of abdominal segments II-VII or III-VII (rarely reduced to a single pore on each side of each segment) and usually scattered over median areas of the thorax. Trilocular pores moderately numerous and evenly distributed. Oral collar tubular ducts of 2 sizes; smaller ducts present sparsely in rows across median areas of abdominal segments II-VII; larger ducts present in marginal groups on head and all thoracic and abdominal segments, and scattered over median area of thorax. Simple pores slightly smaller than the trilocular pores, sparsely but evenly distributed.

Dorsum. Multilocular disc pores absent. Tubular ducts, larger than the larger ducts on the venter and without apparent rims, usually present singly adjacent to some abdominal cerarii. Trilocular pores as for venter. Simple pores about a third of the size of the trilocular pores, present in small groups on mid-line of thoracic segments. Setae long and flagellate, 1 or 2 setae sometimes bifurcate, longest seta on abdominal segments VI or VII 40–100 μm long.

MATERIAL EXAMINED

14 ♀ (including type material listed below) (all BMNH).

Holotype ♀, **Uganda**: Sebei, on roots of *Vernonia auriculifera*, 18.ii.1957 (*D. N. McNutt*). Paratypes, 5 ♀, same data as holotype.

DISTRIBUTION. Afrotropical Region: Mozambique, Nigeria, Sudan, Uganda.

HOSTPLANTS. Occurring on the roots. Anacardaceae: *Anacardium occidentale* (cashew). Asteraceae: *Vernonia auriculifera*. Leguminosae: *Glycine max* (soya bean). Sterculiaceae: *Theobroma cacao*. Also recorded from the roots of *Cassia petersiana* (Leguminosae) by De Lotto (1964).

REMARKS. This species is clearly a member of the *P. citri*-group by virtue of its distribution of multilocular disc pores and tubular ducts. It is similar to *P. ficus* and *P. halli* which may also have long dorsal setae, but differs from both of these species by usually having numerous marginal tubular ducts on the head and thorax. It is most similar to *P. subterraneus*, known only from the holotype, which lacks tubular ducts on the head and has many bifurcate dorsal setae.

Planococcus furcisetosus Mamet

(Fig. 13)

Planococcus furcisetosus Mamet, 1959: 404. Syntypes ♀, MADAGASCAR: on ebenier (MNNH) [2 syntypes examined].

ADULT FEMALE. Mounted specimens broadly oval to rotund, length 1.6–1.8 mm, width 1.2–1.3 mm. Margin of body with a complete series of 18 pairs of cerarii, each with 2 conical setae. Legs stout; hind trochanter + femur 235–260 μm long, hind tibia + tarsus 220–240 μm long; ratio of lengths of hind tibia + tarsus to hind trochanter + femur about 0.92; translucent pores present on hind coxae and tibiae. Inner edges of ostioles well sclerotized. Circulus small and round, width 55–70 μm. Cisanal setae shorter than anal lobe setae. Anal lobe cerarii each situated on a small, moderately sclerotized area.

Venter. Multilocular disc pores confined to median areas of abdomen, present around vulva and in rows across posterior edges of median areas of abdominal segments III-VI. Trilocular pores moderately numerous and evenly distributed. Oral collar tubular ducts apparently of 1 size, present in rows across median areas of abdominal segments III-VII and in marginal groups on segments VII-IX. Simple pores not apparent on specimens examined.

Dorsum. Multilocular disc pores and tubular ducts absent. Trilocular pores moderately numerous and evenly distributed. Simple pores slightly larger than the trilocular pores, present in small

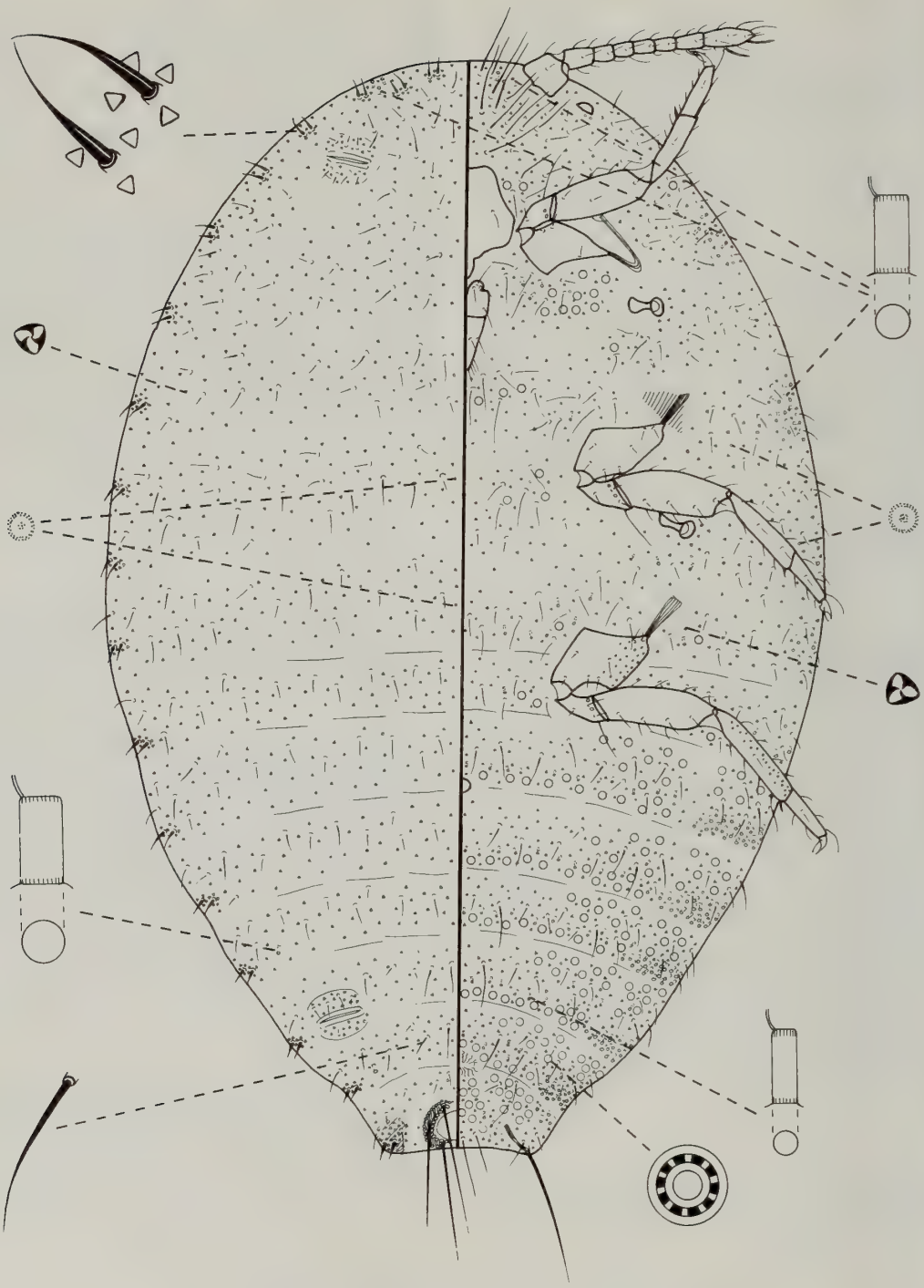

Fig. 12 *Planococcus flagellatus* De Lotto.

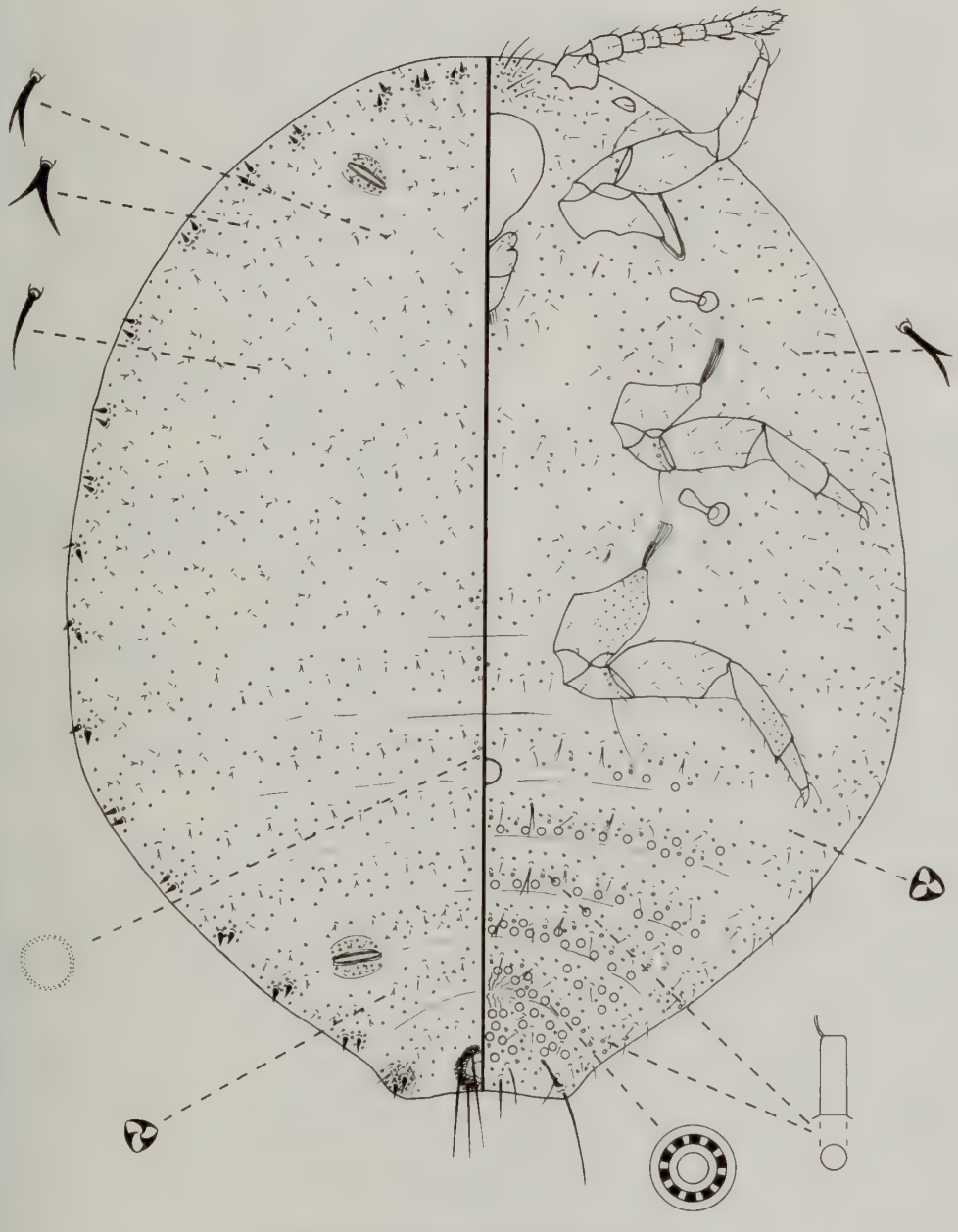

Fig. 13 *Planococcus furcisetosus* Mamet.

groups on the mid-line of the anterior abdominal segments. Setae short and stout, most furcate, longest seta of abdominal segments VI or VII 22–25 μm long.

MATERIAL EXAMINED
2 syntype ♀, **Madagascar**: Maroantsetra, Ambodivoany, on ebenier, iii.1952 (*R. Paulian*) (MNNH).

DISTRIBUTION. Malagasian Region: Madagascar.

HOSTPLANT. Ebenaceae: *Diospyros* sp.

REMARKS. The furcate dorsal setae distinguish *P. furcisetosus* from all other known species of *Planococcus*.

Planococcus halli Ezzat & McConnell (Fig. 14)

Planococcus halli Ezzat & McConnell, 1956: 81. Holotype ♀, ST KITTS: on *Dioscorea* sp. (USMN) [examined].

ADULT FEMALE. Mounted specimens oval, length 1.5–3.4 mm, width 0.9–2.4 mm. Margin of body with a complete series of 18 pairs of cerarii, each with 2 conical setae which are more slender and flagellate towards the anterior end of the body. Legs elongate; hind trochanter + femur 220–335 μm long, hind tibia + tarsus 275–371 μm long, ratio of lengths of hind tibia + tarsus to hind trochanter + femur 1.03–1.24; translucent pores apparent on hind coxae and tibiae. Inner edges of ostioles lightly sclerotized. Circulus quadrate, width 55–180 μm. Cisanal setae shorter than anal lobe setae. Anal lobe cerarii each situated on a moderately sized, lightly sclerotized area.

Venter. Multilocular disc pores situated around vulva and in rows (usually single, except in very large specimens where they may be double) across posterior edges of median areas of abdominal segments II-VII or III-VII, in single rows across anterior edges of median areas of abdominal segments IV-VII, in marginal groups on either side of segments III-VII or IV-VII (rarely 1 or 2 pores present on margins of segment II), and a few pores sometimes scattered over median areas of head and thorax. Trilocular pores numerous and evenly distributed. Oral collar tubular ducts of 2 sizes; smaller ducts present sparsely in rows across median areas of abdominal segments VI or VII; larger ducts present in rows across median areas of segments II-VII, in marginal groups on abdominal segments I-IX, scattered over median areas of thorax, 1–3 ducts sometimes present on head and 1–6 ducts sometimes present on each side of each thoracic segment. Simple pores slightly smaller than the trilocular pores, scattered over entire venter.

Dorsum. Multilocular disc pores absent. Tubular ducts, if present, larger than those on the venter and without apparent rims, and present singly (rarely in 2s or 3s) adjacent to some abdominal cerarii. Trilocular pores as for venter. Simple pores of 2 sizes; larger pores slightly larger than the trilocular pores, present in small groups on mid-line of each abdominal segment; smaller pores minute, scattered over entire dorsum. Setae long and flagellate, length of longest seta of abdominal segments VI or VII 25–45 μm.

MATERIAL EXAMINED
About 100 ♀ (including holotype) (BMNH, USNM).
Holotype ♀, **St Kitts** (intercepted at Boston, Massachusetts): on *Dioscorea* sp., yam, 12.iii.1949 (*Hodson Hardy*) (USNM). Originally described from the holotype only.

DISTRIBUTION. Afrotropical Region: Cameroons, Ethiopia, Gabon, Ghana, Liberia, Nigeria, South Africa, Sudan. Neotropical Region: Barbados, Bermuda, Brazil, Guyana, Haiti, St. Kitts, Trinidad.

HOSTPLANTS. Celestraceae: *Gymnosporia spinosa*. Dioscoreaceae: *Dioscorea alata*, *D. rotundata*. Euphorbiaceae: *Manihot esculentum*. Leguminosae: *Arachis hypogaea* (groundnut). Poaceae: *Saccharum officinarum*. Rubiaceae: *Coffea canephora*. Most commonly encountered on yams (*Dioscorea* spp.).

REMARKS. *P. halli* is very similar to *P. ficus*, and some specimens may be impossible to identify by the characters given in the key. Cox & Wetton (in press) carried out multivariate analyses of specimens of this group from yams, pomegranates, figs and grapevines. The results showed that the specimens from yams were differentiated almost entirely from those from figs, pomegranates and grapevines, and that specimens from yams from the Ethiopian Region and from the West Indies were intermingled. That this differentiation was not merely a host effect was demonstrated by rearing material from each source on potato tubers. Cox & Wetton (in press) concluded that, as two names are available, the two groups should be regarded for the present as separate species.

The two species differ by the frequent presence of a group of multilocular disc pores behind the front coxae in *P. ficus* (never present in *P. halli*), the frequent occurrence of translucent pores on the hind femora in *P. ficus* (never present in *P. halli*), multilocular disc pores usually extending

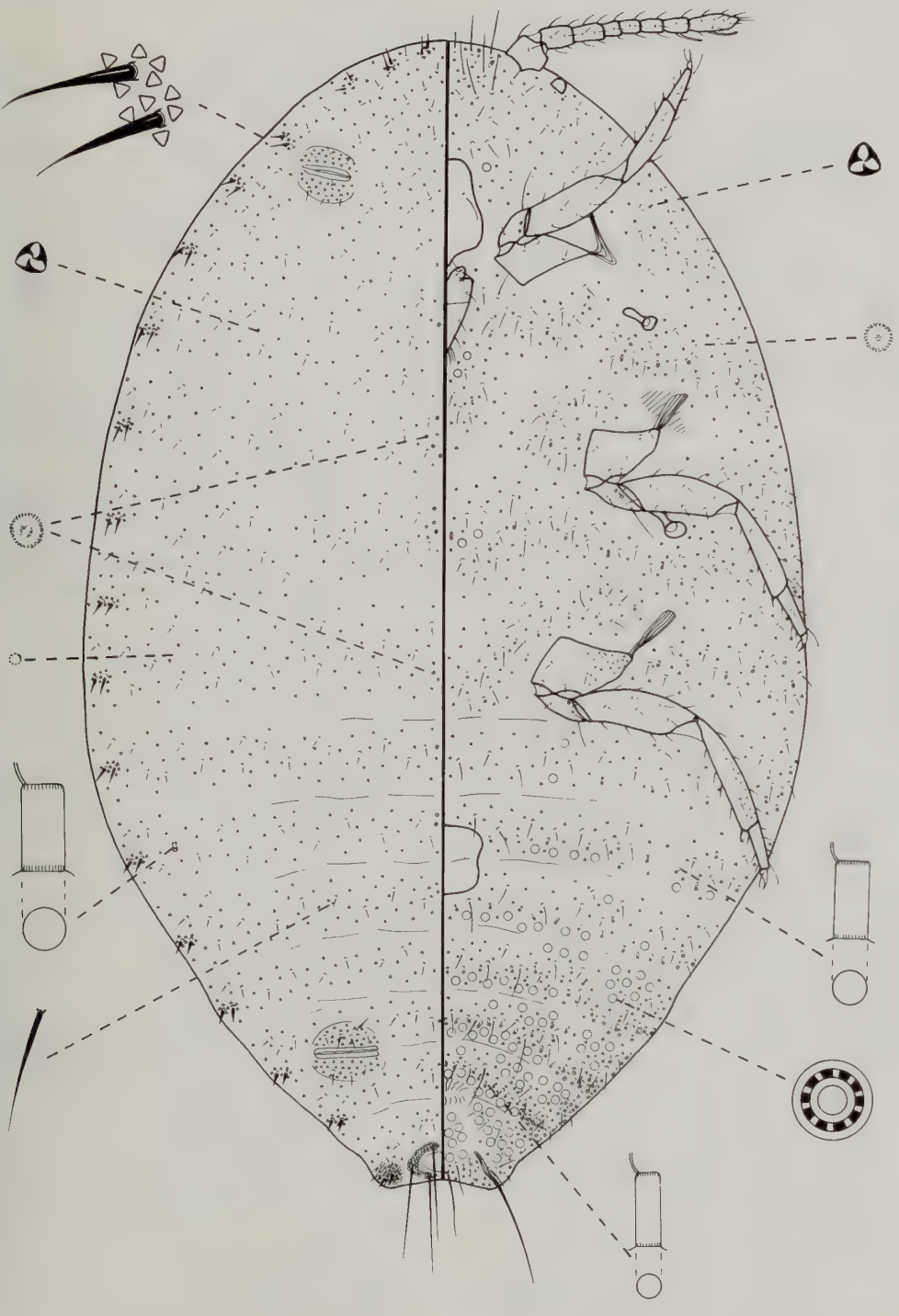

Fig. 14 *Planococcus halli* Ezzat & McConnell.

further forwards on the marginal than on the median areas of the body (the reverse situation usually occurring in *P. halli*), and large simple pores seldom apparent on the midline of the abdominal segments in *P. ficus* (always apparent in *P. halli*).

Specimens from the Sudan and Ethiopia differ from the usual forms of both *P. ficus* and *P. halli*. More work is needed on this complex, preferably carried out locally where live material would be available for experimentation.

Economic status. *P. halli* is frequently intercepted in the U.S.A. and the U.K. on yam tubers from Nigeria and the West Indies.

Planococcus hospitus De Lotto

(Fig. 15)

Planococus hospitus De Lotto, 1961 : 221. Holotype ♀, Uganda: on *Eulophia* (BMNH) [examined].

Adult female. Mounted specimen rotund, length 1.8 mm, width 1.4 mm. Margin of body with a complete series of 18 pairs of cerarii, each with 2 conical setae which are stout on abdominal segments but more slender on head. Legs stout; hind trochanter + femur 220 μm long, hind tibia + tarsus 200 μm long; ratio of lengths of hind tibia + tarsus to hind trochanter + femur 0.91; translucent pores not apparant on hind legs. Inner edges of ostioles well sclerotized. Circulus small and oval, width 65 μm. Cisanal setae shorter than anal lobe setae. Anal lobe cerarii each situated on a small, lightly sclerotized area.

Venter. Multilocular disc pores confined to median areas of abdomen, present around vulva and in single rows across posterior edges of median areas of abdominal segments V or VI. Trilocular pores moderately numerous and evenly distributed. Oral collar tubular ducts of 1 size, confined to median areas of abdomen, present in single rows across median areas of abdominal segments IV-VII. Simple pores about the same size as the multilocular disc pores, lightly sclerotized, and scattered over entire venter. Setae on median areas long, fine and flagellate, but those on margins moderately long and fine, and with indistinctly knobbed tips.

Dorsum. Multilocular disc pores and tubular ducts absent. Trilocular pores numerous and evenly distributed. Simple pores of 2 sizes, pores about twice the size of the trilocular pores scattered over entire dorsum, larger pores in groups on mid-line of thoracic and abdominal segments. Setae moderately long and fine, and with indistinctly knobbed tips; length of longest seta on abdominal segments VI or VII about 30 μm.

Material examined

Holotype ♀, **Uganda**: Kampala, on tubers of *Eulophia* sp., 18.x.1956 (*A. G. P. Michelmore*) (BMNH).

Distribution. Afrotropical Region: Uganda.

Hostplant. Orchidaceae: *Eulophia* sp.

Remarks. This species was originally described from, and is still only known from, a single specimen.

P. hospitus is similar to the other 4 species of *Planococcus* which occur on orchids, *P. hosyni* and *P. orchidi* from the Afrotropical Region, and *P. dendrobii* and *P. philippinensis* from the Oriental Region. All have low numbers of multilocular disc pores and tubular ducts, and have knobbed (although often indistinctly) dorsal setae. *P. hospitus* and *P. hosyni* may be distinguished from the other species by their lack of marginal tubular ducts and from each other by the presence of translucent pores on the hind tibiae and tarsi in *P. hosyni* and by the very large ventral simple pores in *P. hospitus*.

Planococcus hosyni Ezzat & McConnell

(Fig. 16)

Planococcus hosyni Ezzat McConnell, 1956: 83. Holotype ♀, Zimbabwe: on *Aerangis katschii* (USNM) [examined].

Adult female. Mounted specimens oval to rotund, length 1.3–2.1 mm, width 0.8–1.8 mm. Margin of body with a complete series of 18 pairs of cerarii, all with moderately stout conical setae. Legs stout; hind trochanter + femur 180–210 μm long, hind tibia + tarsus 195–210 μm long, ratio of lengths of hind tibia + tarsus to hind trochanter + femur 1.0–1.05; translucent pores present on hind coxae and tibiae. Inner edges of ostioles moderately sclerotized. Circulus small and round, width 47–57 μm. Cisanal setae shorter than anal ring setae. Anal lobes not noticeably sclerotized.

Venter. Multilocular disc pores confined to median areas of abdomen, present around vulva, in a single row across posterior border of median area of abdominal segment VI, and 1–3 pores present on segments IV or V. Trilocular pores moderately numerous and evenly distributed. Oral collar tubular ducts of 1 size, confined to median areas of abdomen, occurring sparsely in rows across median areas of abdominal segments

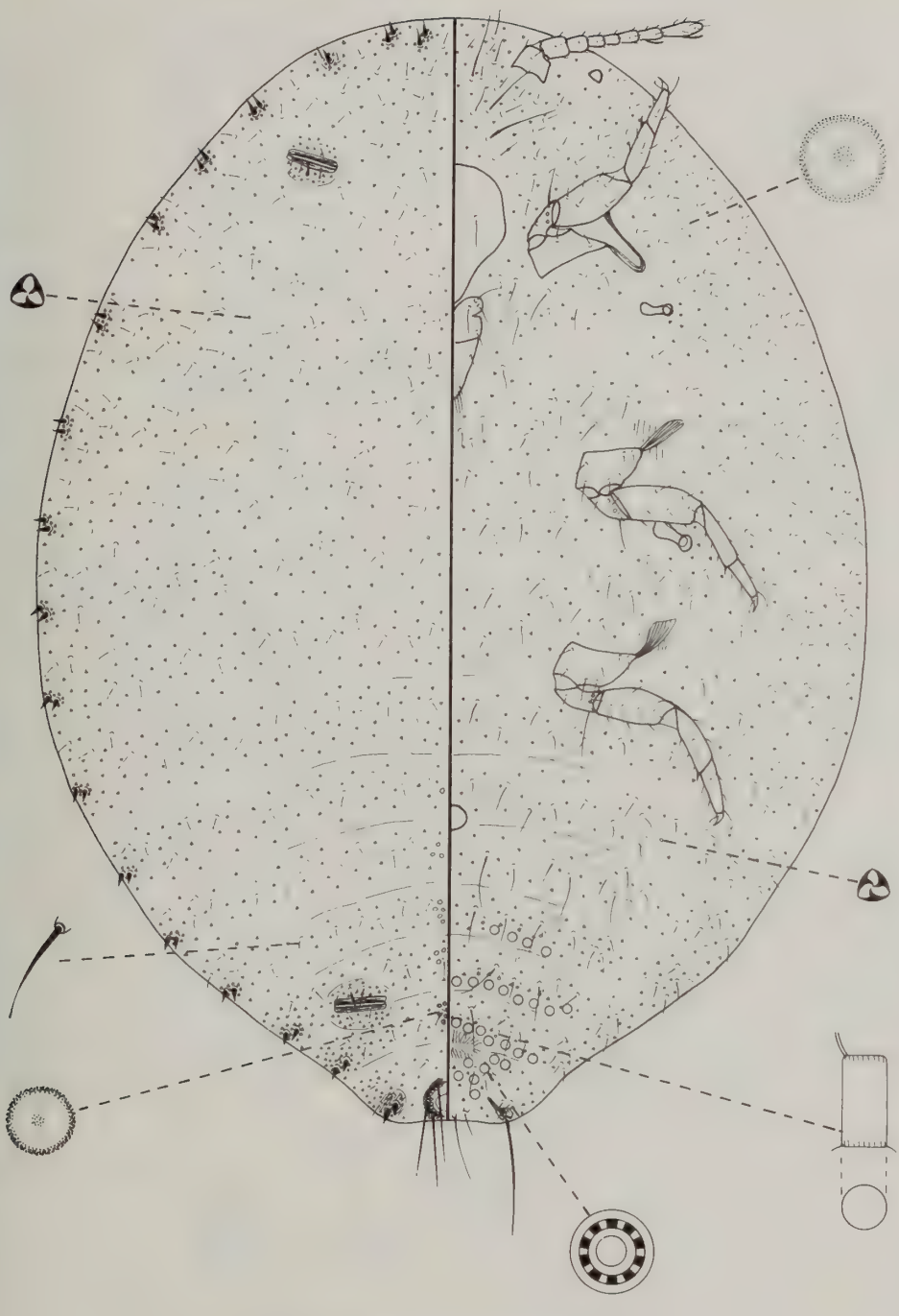

Fig. 15 *Planococcus hospitus* De Lotto.

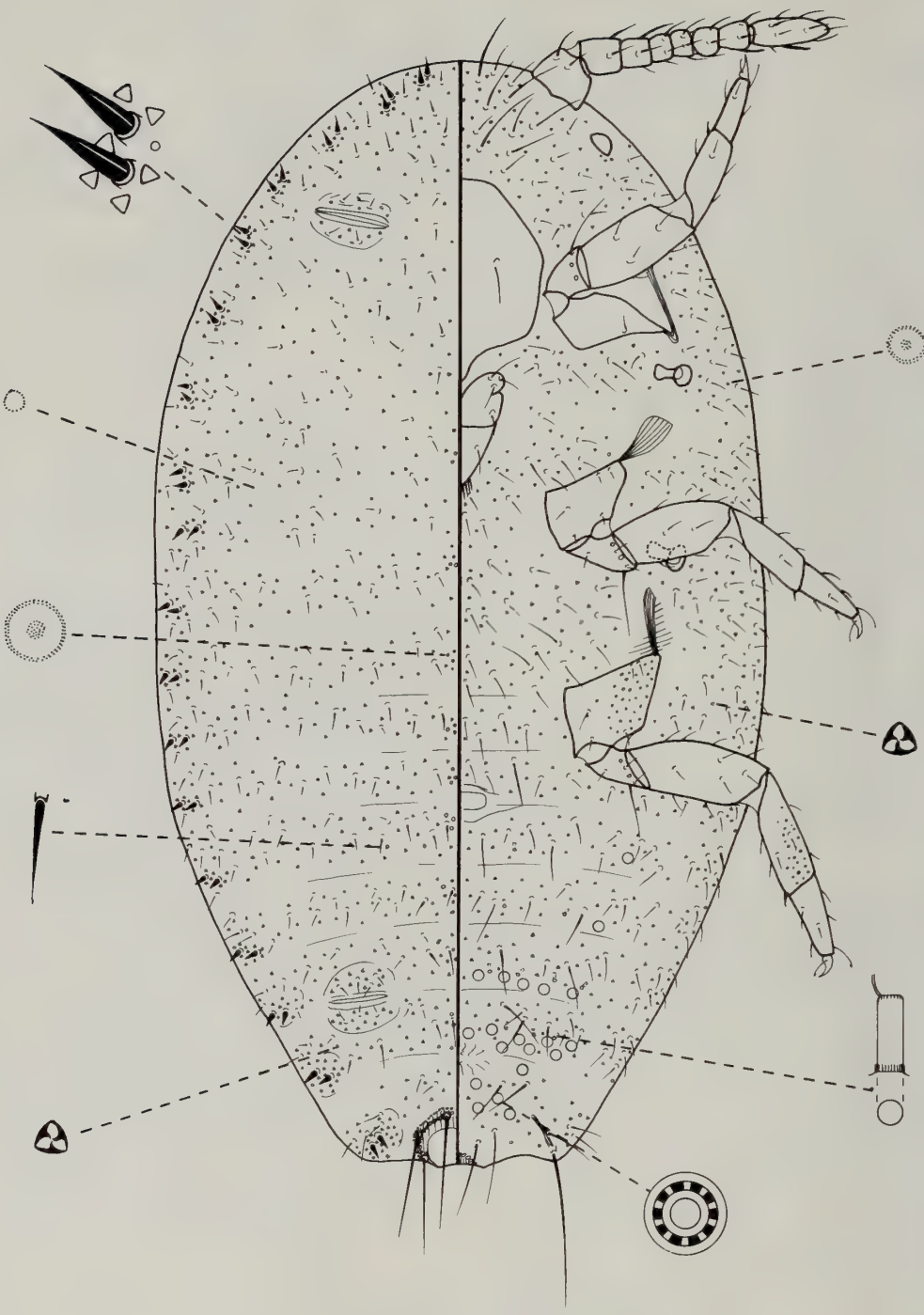

Fig. 16 *Planococcus hosyni* Ezzat & McConnell.

IV-VII. Simple pores about the same size as the trilocular pores, sparsely but evenly distributed.

Dorsum. Multilocular disc pores and tubular ducts absent. Trilocular pores as for venter. Simple pores of 2 sizes, smaller pores smaller than the trilocular pores and sparsely scattered over entire dorsum, larger simple pores slightly larger than the trilocular pores, present in groups on mid-line of thoracic and abdominal segments. Setae moderately long and stout, flagellate but with indistinctly knobbed tips, length of longest seta on abdominal segments VI or VI 23–30 μm.

MATERIAL EXAMINED
5 ♀ (including holotype) (BMNH, USNM).

Holotype ♀, **Zimbabwe** (Rhodesia): on *Aerangis katschii*, 2.vii.1953 (*D. Kamper*) (USNM).

DISTRIBUTION. Afrotropical Region: South Africa, Zimbabwe.

HOSTPLANT. Orchidaceae: *Aerangis katschii*.

REMARKS. This species was originally described from the holotype only. This specimen is a very young adult female – although its body shape is oval, the mature female would probably have been rotund, as in the additional material examined. Other specimens examined from South Africa also on Orchidaceae have the dorsal setae slightly more distinctly knobbed than those of the holotype, but this characteristic can be observed in the latter specimen under high magnification

P. hosyni is most similar to *P. hospitus*, also from the Afrotropical Region, in completely lacking marginal tubular ducts and in having flagellate, yet knobbed, dorsal setae, but can be distinguished by the very large ventral simple pores which are present in *P. hospitus*. The three other known species with knobbed dorsal setae, *P. orchidi* from the Afrotropical Region, and *P. dendrobii* and *P. philippinensis* from the Oriental region, all recorded only from orchids, have marginal tubular ducts on abdominal segments VI or VII and much stouter dorsal setae.

Planococcus japonicus sp. n.

(Fig. 17)

[*Planococcus azaleae* (Tinsley) Ezzat & McConnell, 1956: 63. Misidentification.]

ADULT FEMALE. Mounted specimens oval, length 1.5–3.9 mm, width 0.9–2.3 mm. Margin of body with a complete series of 18 pairs of cerarii, cephalic and thoracic pairs each with 2–5 conical setae and abdominal pairs each with 2 conical setae. Legs elongate, hind femur + trochanter 240–315 μm long, hind tibia + tarsus 275–340 μm long, ratio of lengths of hind tibia + tarsus to hind trochanter + femur 1.03–1.17; translucent pores present on hind coxae and tibiae. Inner edges of ostioles lightly sclerotized. Circulus quadrate, width 80–145 μm. Cisanal setae shorter than anal ring setae. Anal lobe cerarii each situated on a small, moderately sclerotized area.

Venter. Multilocular disc pores situated around vulva, in rows across posterior edges of median areas of abdominal segments III-VII or IV-VII and across anterior edges of segments V-VII, a few pores present on margins of segments VI or VII, up to 7 pores situated on head and 5–16 pores scattered over median areas of thorax. Oral collar tubular ducts of 2 sizes; smaller ducts present in rows across median areas of abdominal segments II-VII; larger ducts present in rows across median areas of segments IV-VI, in marginal groups on segments I-VIII, in a larger marginal group on each side of prothorax and a few ducts sometimes present on head and margins of mesothorax. Trilocular pores evenly distributed. Simple pores minute, scattered over venter.

Dorsum. Multilocular disc pores absent. Some specimens (including the holotype) with 1 or 2 tubular ducts with distinct rims present on the head. Trilocular pores and simple pores as for venter. Setae short and stout, sometimes almost conical or lanceolate, longest seta on abdominal segments VI or VII 15–20 μm long.

MATERIAL EXAMINED
Holotype ♀, **Japan**: Fukuoka, Ryugezi, on *Pyrus* sp., 6.vi.1968 (*Hiroshi Kajita*) (USNM).
Paratypes. **Japan**: 2 ♀, same data as holotype; 1 ♀, (intercepted at Anchorage), on *Eriobotrya japonica* fruit, 8.vi.1971 (*D. Husnik*) (USNM); 1 ♀, (intercepted at Seattle), on *Eriobotrya japonica* fruit, 8.vi.1971 (*R. F. Goodall*) (USNM); 12 ♀, (at National Arboretum, Washington, D.C.), on *Rhododendron indicum* stem, 3.viii.1978 (*S. Nakahara & R. Brittingham*) (BMNH, USNM).

DISTRIBUTION. Palaearctic Region: Japan.

HOSTPLANTS. Ericaceae: *Rhododendron indicum*. Rosaceae: *Eriobotrya japonica, Pyrus* sp.

REMARKS. This species has frequently been confused with *Crisicoccus azaleae* Tinsley, and was redescribed and illustrated as *Planococcus azaleae* by Ezzat & McConnell (1956). The latter species has fewer pairs of cerarii and has much more flagellate dorsal setae than does *P. japonicus* (Fig. 18). Some of the material listed above was labelled as *Crisicoccus matsumotoi* (Shiraiwa), but this species has very long flagellate dorsal

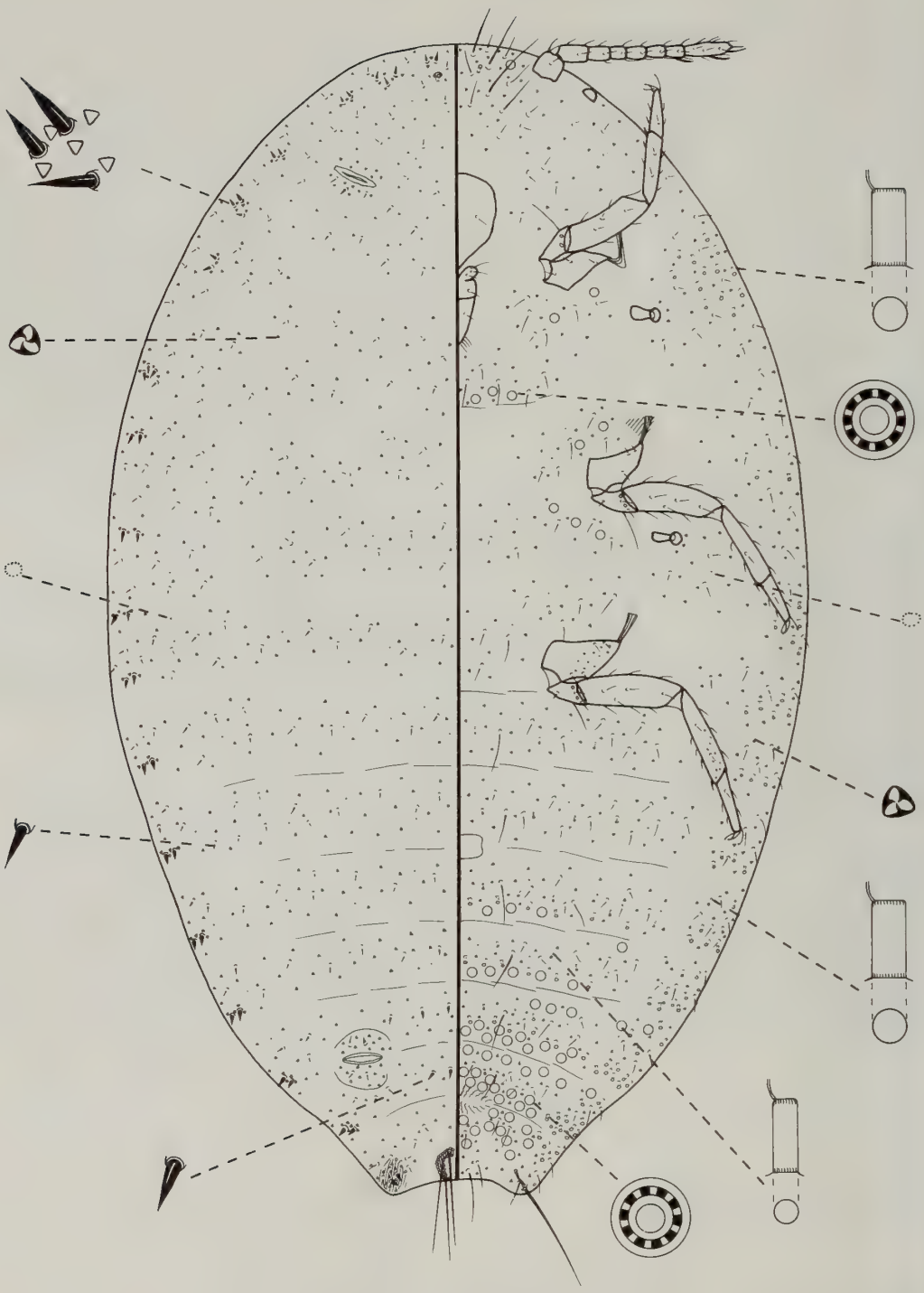

Fig. 17 *Planococcus japonicus* sp. n.

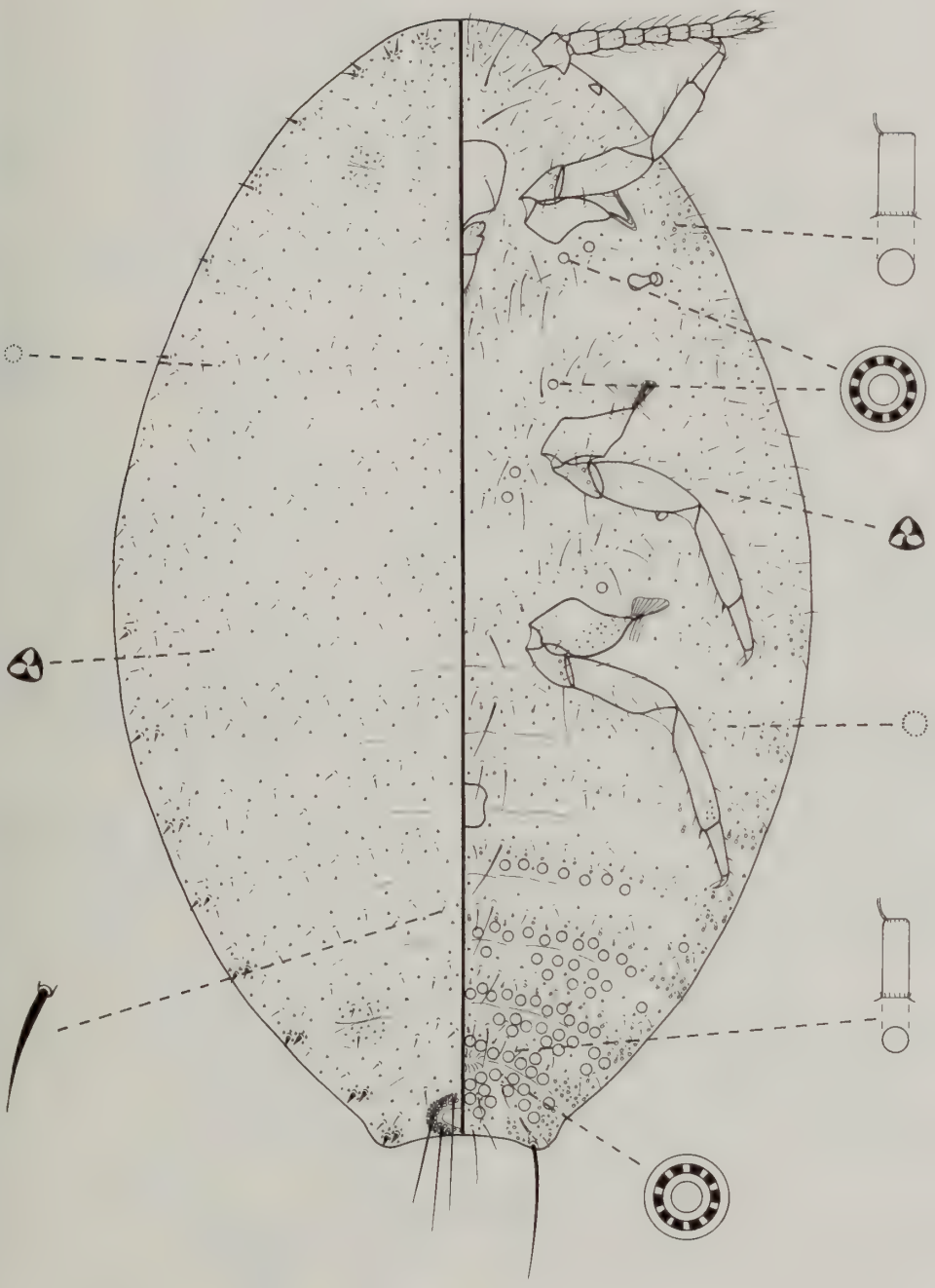

Fig. 18 *Crisicoccus azaleae* (Tinsley)

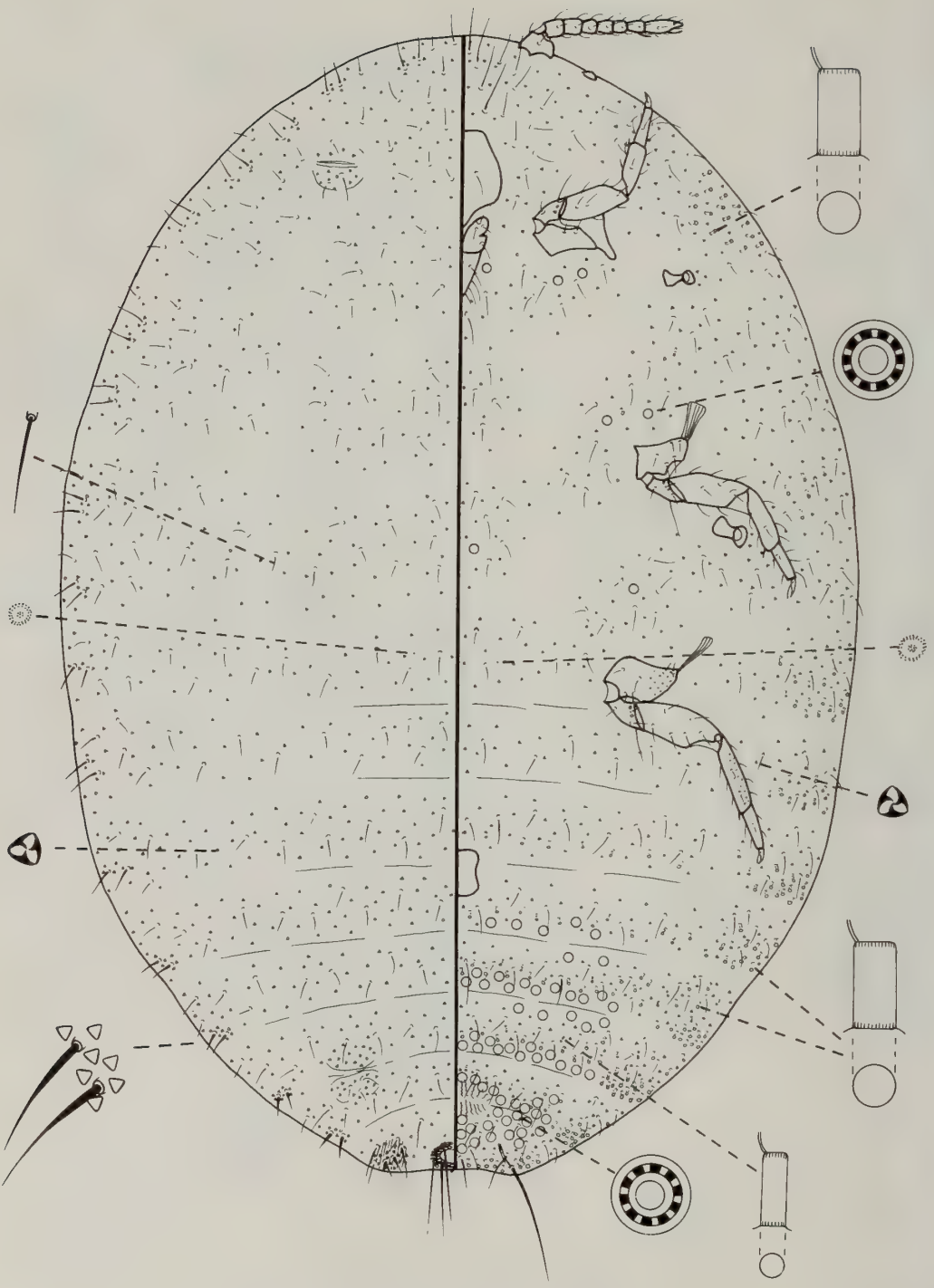

Fig. 19 *Crisicoccus matsumotoi* (Shiraiwa).

setae (Fig. 19). It is quite probable that all three of these species are related, as the distinction of *Crisicoccus* from *Planococcus* is only by the loss of cerarii in the former genus.

P. japonicus is very similar to *P. mali* which, at present, is known only from New Zealand and Australia. It differs from *P. mali* by having smaller legs and a larger group of oral collar tubular ducts on each side of the prothorax. The separation of these two species is discussed in more detail under *P. mali*.

ECONOMIC STATUS. This species caused heavy infestations on *Rhododendron* at the National Arboretum, Washington D.C. in 1978.

Planococcus kenyae (Le Pelley)

(Fig. 20)

Pseudococcus citri var. *congoensis* Newstead; Mann, 1922: 629. Nomen nudum.
Pseudococcus kenyae Le Pelley, 1935: 185. Holotype ♀, KENYA: on *Coffea arabica* (BMNH, ?missing) [not examined].
Pseudococcus kenyaensis Betrem 1936: 129. Nomen nudum.
Planococcus kenyae (Le Pelley) Ferris, 1950: 164.
Planococcus subukiaensis De Lotto, 1954: 110. Holotype ♀, KENYA: on *Coffea arabica* (BMNH) [examined]. **Syn. n.**

ADULT FEMALE. Mounted specimens oval to rotund, length 1.4–2.7 mm, width 0.8–2.0 mm. Margin of body with a complete series of 18 pairs of cerarii, all with moderately stout conical setae. Legs elongate; hind trochanter + femur 225–340 μm long, hind tibia + tarsus 250–355 μm long, ratio of lengths of hind tibia + tarsus to hind trochanter + femur 0.97–1.11; translucent pores present on hind coxae and tibiae. Inner edges of ostioles moderately sclerotized. Circulus quadrate and of moderate size, width 50–160 μm. Cisanal setae usually noticeably longer than anal ring setae. Anal lobe cerarii each situated on a large, pronounced, sclerotized area which is apparent only in well-stained specimens.

Venter. Multilocular disc pores usually confined to median areas of venter, present around vulva and in single rows across posterior borders of median areas of abdominal segments IV-VII, a few pores sometimes present on anterior borders of median areas of abdominal segments VI and/or VII and on margins of segments V-VII. Trilocular pores moderately numerous and evenly distributed. Oral collar tubular ducts of 2 sizes; smaller ducts occurring sparsely in rows across median areas of abdominal segments VI or VII; larger ducts present in rows across median areas of all abdominal segments, usually sparsely scattered over median areas of thorax, and often present singly or in small marginal groups around entire venter, a single duct often located adjacent to each postocular cerarius. Simple pores about the same size as the trilocular pores, sparsely but evenly distributed.

Dorsum. Multilocular disc pores and tubular ducts absent. Trilocular pores as for venter. Simple pores of 2 sizes, smaller size smaller than the trilocular pores and sparsely scattered over entire dorsum, larger size about twice the size of the trilocular pores in groups on mid-line of abdominal segments I-V. Setae flagellate and moderately short and stout, length of longest seta on abdominal segments VI or VI usually 15–26 μm, rarely up to 40 μm.

MATERIAL EXAMINED
Over 100 ♀ (including type material listed) (BMNH, MNNH).
Pseudococcus kenyae. Holotype ♀ apparently missing. Paratypes, 8 o, **Kenya**: Nairobi, Scott Agri. Lab., on *Coffea arabica*, 1.iii.1935 (*P. B. Notley*); 1 ♀, same data except 23.vi.1933 (BMNH).
Planococcus subukiaensis. Holotype ♀, **Kenya**: Subukia, ex *Coffea arabica*, 8.vii.1933 (no collector) (BMNH). Paratypes, 5 ♀, same data as holotype (BMNH, USNM). The original description of *P. subukiaensis* states that the host plant is unknown, but it is given as *Coffea arabica* on the slide labels and by De Lotto (1964).

DISTRIBUTION. Afrotropical Region: Central African Republic, Ghana, Kenya, Nigeria, Congo, Sudan, Tanzania, Togo, Uganda, Zaire, Zimbabwe.

HOSTPLANTS. Anacardaceae: *Lannea discola*. Costaceae: *Costus* sp. Euphorbiacae: *Croton* sp. Leguminosae: *Inga* sp. Loranthaceae: *Loranthus* sp. Malvaceae: *Hibiscus gossypinus*. Passifloraceae: *Barteria fistulosa*. Rubiaceae: *Coffea* sp. *C. arabica*, *Cuviera angloensis*, *Leptactinia* sp. Sterculiaceae: *Theobroma cacao*.

REMARKS. *P. kenyae* is readily recognised by its prominent anal lobes, long cisanal setae, multilocular disc pores largely restricted to the posterior borders of the median areas of the abdominal segments and relatively few marginal tubular ducts. It is superficially similar to *P. lilacinus* in having long cisanal setae and multilocular disc pores absent from the margins of the venter, but it lacks the noticeably stout legs and very long dorsal setae of *P. lilacinus*. It is also

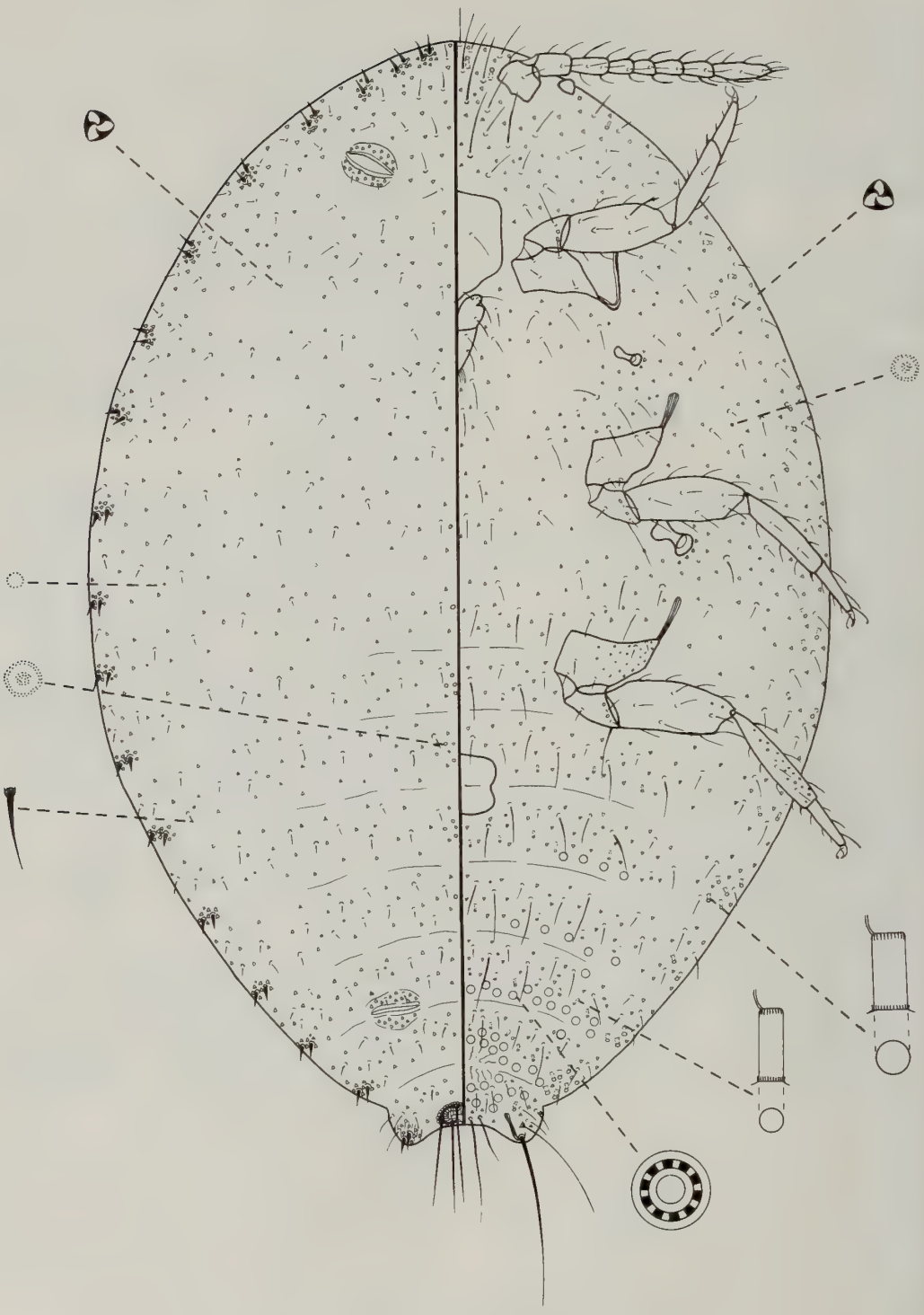

Fig. 20 *Planococcus kenyae* (Le Pelley).

similar to *P. hosnyi* which is known only from the holotype, but differs by having relatively longer cisanal setae, elongate legs, and tubular ducts present on the margins of the body.

P. subukiaensis was described by De Lotto (1954) and redescribed by Ezzat & McConnell (1956) on the basis of a single series of specimens. These were said to differ from *P. kenyae* by lacking the dorsal sclerotized area around the anal lobe cerarii, by having more tubular ducts and multilocular disc pores on the abdomen and by lacking tubular ducts anterior to the circulus. Reexamination of the type-specimens during the course of the present study shows these specimens to have been over-macerated, with the result that the dorsal sclerotization of the dorsal lobes is not apparent. Furthermore there are, in fact, a few tubular ducts present on the margins of the head and thorax in all these specimens. The anal lobe area is somewhat damaged in all the specimens, but in one instance the cisanal seta is clearly elongate as in normal *P. kenyae*. Studied in conjunction with all the material listed below, the type-material of *P. subukiaenis* shows no noticeable deviation from the pattern of variation observed for *P. kenyae*, and the species is consequently here synonomized.

Mann (1922) published the name *Pseudococcus citri* var. *congoensis* Newstead for some ant-attended mealybugs found on *Barteria fistulosa* and *Cuviera angolensis* in the Republic of the Congo. He states that the species was apparently still undescribed, but had been identified by Prof. R. Newstead. Specimens which are undoubtedly those seen by Newstead are in the BMNH and have been identified here as *P. kenyae*.

Economic status. *P. kenyae* is a major pest of coffee in Kenya. The history of its identification highlights one of the common problems encountered in the implementation of biological control programmes. In 1923 a mealybug was found causing considerable damage to coffee in Kenya. As biological control was known to be a sucessful way of controlling coccoids, parasites were sought for its control. The mealybug was initially identified as the citrus mealybug *P. citri* for which parasites were available in California. These were introduced into Kenya and tested against the coffee mealybug, but the results were unsuccessful. The mealybug was then redetermined as *P. lilacinus*, an Oriental species. Parasites were collected from south-east Asia, taken to Africa, and tested against the coffee mealybug, again without success. Finally, 12 years after this mealybug became a problem, it was recognized as being an undescribed species and appropriate parasites found for it in the neighbouring African countries (Le Pelley, 1935; 1943a). It is interesting that the specimens labelled as *Pseudococcus citri* var. *congoensis* by Newstead, discussed above, were collected in 1919. To date, *P. kenyae* is known only from the Afrotropical Region.

Planococcus kraunhiae (Kuwana)

(Fig. 21)

Dactylopius kraunhiae Kuwana, 1902: 55. Syntypes ♀, Japan: on *Wisteria floribunda* (as '*Kraunhia floribunda*') (location of types not known) [not examined].

Pseudococcus kraunhiae (Kuwana) Fernald, 1903: 104.

Planococcus kraunhiae (Kuwana) Ferris, 1950: 158; Ezzat McConnell, 1956: 87; McKenzie, 1967: 283.

Planococcus siakwanensis Borchsenius, 1962: 586. Holotype ♀, China: on undetermined host (ZIL) [not examined]. **Syn. n.**

Adult female. Mounted specimens oval, length 2.0–3.3 mm, width 1.1–2.0 mm. Margin of body with a complete series of 18 pairs of cerarii, each with 2 slender conical setae, slightly swollen at the base, more slender towards the anterior end of the body. Legs elongate; hind trochanter + femur 285–375 μm long, hind tibia + tarsus 305–430 μm long, ratio of lengths of hind tibia + tarsus to hind trochanter + femur 1.06–1.20; translucent pores present on hind coxae and tibiae. Inner edges of ostioles lightly sclerotized. Circulus small and quadrate, width 80–190 μm. Cisanal setae shorter than anal ring setae. Anal lobe cerarii each situated on a small, lightly sclerotized area which is apparent only in well-stained specimens.

Venter. Multilocular disc pores present around vulva, in single or double rows across posterior edges of median areas of abdominal segments II-VII, in single rows across anterior edges of segments III-VII or IV-VII, 1–4 pores present on each margin of segments V-VII, and a few pores scattered over thorax. Trilocular pores moderately numerous and evenly distributed. Oral collar tubular ducts of 2 sizes; smaller size occurring sparsely in rows across median areas of abdominal segments III-VII; larger size in rows across median areas of segments II-VI, sparsely scattered over median areas of thorax and present in small marginal groups on head and thorax and in larger groups on margins of abdominal segments. Simple pores about half the size of the trilocular pores, very sparsely scattered over abdominal segments only.

Dorsum. Multilocular disc pores absent. Trilocular pores moderately numerous and generally

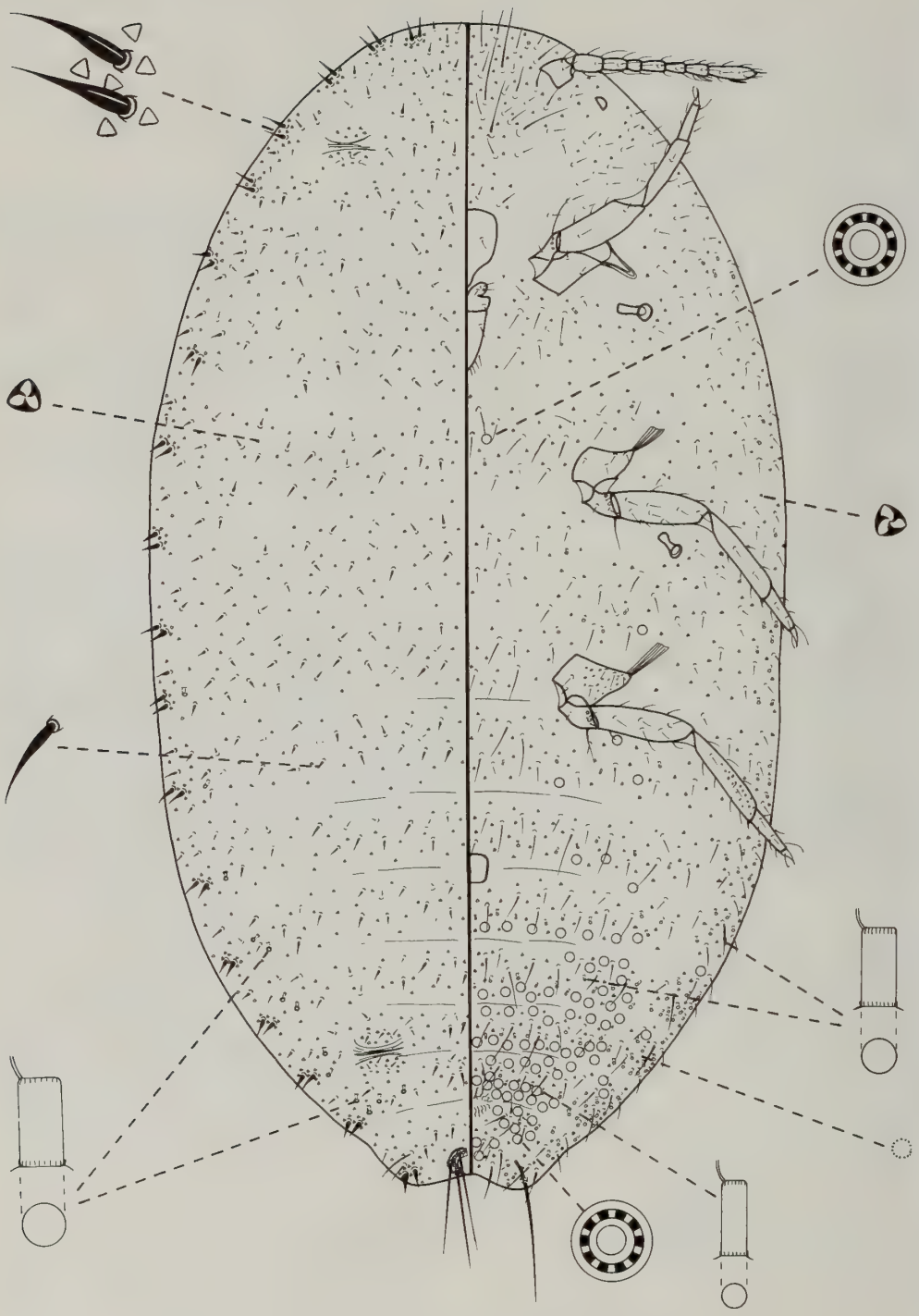

Fig. 21 *Planococcus kraunhiae* (Kuwana).

evenly distributed, but 1 or 2 pores sometimes associated with the bases of some of the larger setae. Tubular ducts, larger than the larger size on the venter and without apparent rims, variable in number, present in groups of 2–5 ducts adjacent to at least some abdominal cerarii, sometimes also sparsely in rows across some abdominal segments. Simple pores apparently absent. Setae with flagellate tips and distinctly swollen bases, length of longest seta on abdominal segments VI or VI 18–26 μm.

MATERIAL EXAMINED

19 ♀ (including type material listed below) (BMNH, ZIL, UCD, USNM).

Planococcus siakwanensis Borchsenius. 1 paratype ♀, **China:** Yunnan Province, nr Siakwan, on branches of an undetermined shrub, 17.iv.1957 (*Borchsenius*) (ZIL).

DISTRIBUTION. Palearctic Region: Korea (intercepted in U.S.A.), Japan. Oriental Region: China. Nearctic Region: U.S.A., California. Frequently intercepted in the U.S.A. on fruit imported from Japan.

HOSTPLANTS. Ebenaceae: *Diospyros kaki*. Leguminosae: *Wisteria* sp. Rutaceae: *Citrus* sp. Also recorded from *Wisteria floribunda* (as '*Kraunhia floribunda*') (Kuwana, 1902), *Ficus carica* (Moraceae), *Plantanus orientalis* (Plantanaceae), *Citrus noblis* var. *unshiu*, *Citrus paradisi* and *Ilex* sp. (Aquifoliaceae) (McKenzie, 1967). Some of these records may be based on misidentifications.

The records by Ezzat & McConnell (1956) on croton (*Croton* sp., Euphorbiaceae) from Jamaica (intercepted in U.S.A.) and *Olea chrysophylla* (Oleaceae) from Eritrea, Ethiopia are regarded here as being dubious. Specimens of the latter record have been located and are a species of *Delottococcus*.

REMARKS. This is apparently an eastern Palaearctic species that has been introduced into the U.S.A.

P. kraunhiae is characterised by having only a few multilocular disc pores on the margins of the abdomen, short, stout dorsal setae with swollen bases and flagellate tips, and groups of 2–5 tubular ducts on the dorsum adjacent to most of the abdominal cerarii. *P. kraunhiae* could be confused with two other species that often have similar numbers and distribution of dorsal tubular ducts, *P. ficus* and *P. vovae*. It differs from *P. ficus* by having considerably fewer multilocular disc pores on the margins of the abdominal segments and by having differently shaped dorsal setae (slender and flagellate in *P. ficus*), and from *P. vovae* by having at least a few multilocular disc pores on the margins of the abdominal segments and by the same difference in the shape of the dorsal setae as in *P. ficus*. The swollen-based dorsal setae may cause it to be confused with the *dorsospinosus*-group, but these species never have marginal multilocular disc pores, and have the trilocular pores much more aggregated around the bases of the dorsal setae.

The paratype of *P. siakwanensis* examined fits within the observed variation of *P. kraunhiae* collected from other parts of the world. The type specimens of *P. siakwanensis* represent the only material of *P. kraunhiae* known from China.

Planococcus lilacinus (Cockerell)

(Fig. 22)

Pseudococcus lilacinus Cockerell, 1905: 128. Syntypes ♀, PHILIPPINES: on cultivated orange (USNM) [8 syntypes examined].

Pseudococcus tayabanus Cockerell, 1905: 129. Syntypes ♀, PHILIPPINES: on cultivated cacao (USNM) [4 syntypes examined]. [Synonymised by Morrison, 1920: 176.]

Dactylopius crotonis Green, 1906: 44. Nomen nudum.

Dactylopius crotonis Green, 1911: 35. [As new species.] Syntypes ♀, SRI LANKA: on *Castilloa elastica* (BMNH) [4 syntypes examined]. [Synonymised by Morrison, 1920: 176].

Pseudococcus crotonis (Green) Sasscer, 1912: 86.

Pseudococcus deceptor Betrem, 1937: 54. JAVA: on coffee roots (status of type material not known). **Syn. n.**

Tylococcus mauritiensis Mamet, 1939: 579. Holotype ♀, MAURITIUS: on fruits of *Eugenia mespiloides* (BMNH: ?missing) [not examined]. [Synonymized by Ezzat & McConnell, 1956: 89.]

Planococcus crotonis (Green) Ferris, 1950: 164.

Planococcus tayabanus (Cockerell) Ferris, 1950: 164.

Planococcus lilacinus (Cockerell) Ferris, 1950: 164.

[*Planococcus citri* (Risso) Ferris, 1954: 52. Misidentification.]

[*Planococcus citri* (Risso) McKenzie, 1967: 281; illustration only. Misidentification.]

ADULT FEMALE. Mounted specimens broadly oval to rotund, length 1.2–3.1 mm, width 0.7–3.0 mm. Margin of body with a complete series of 18 pairs of cerarii, usually all with stout conical setae, occasionally some of those on head with elongate,

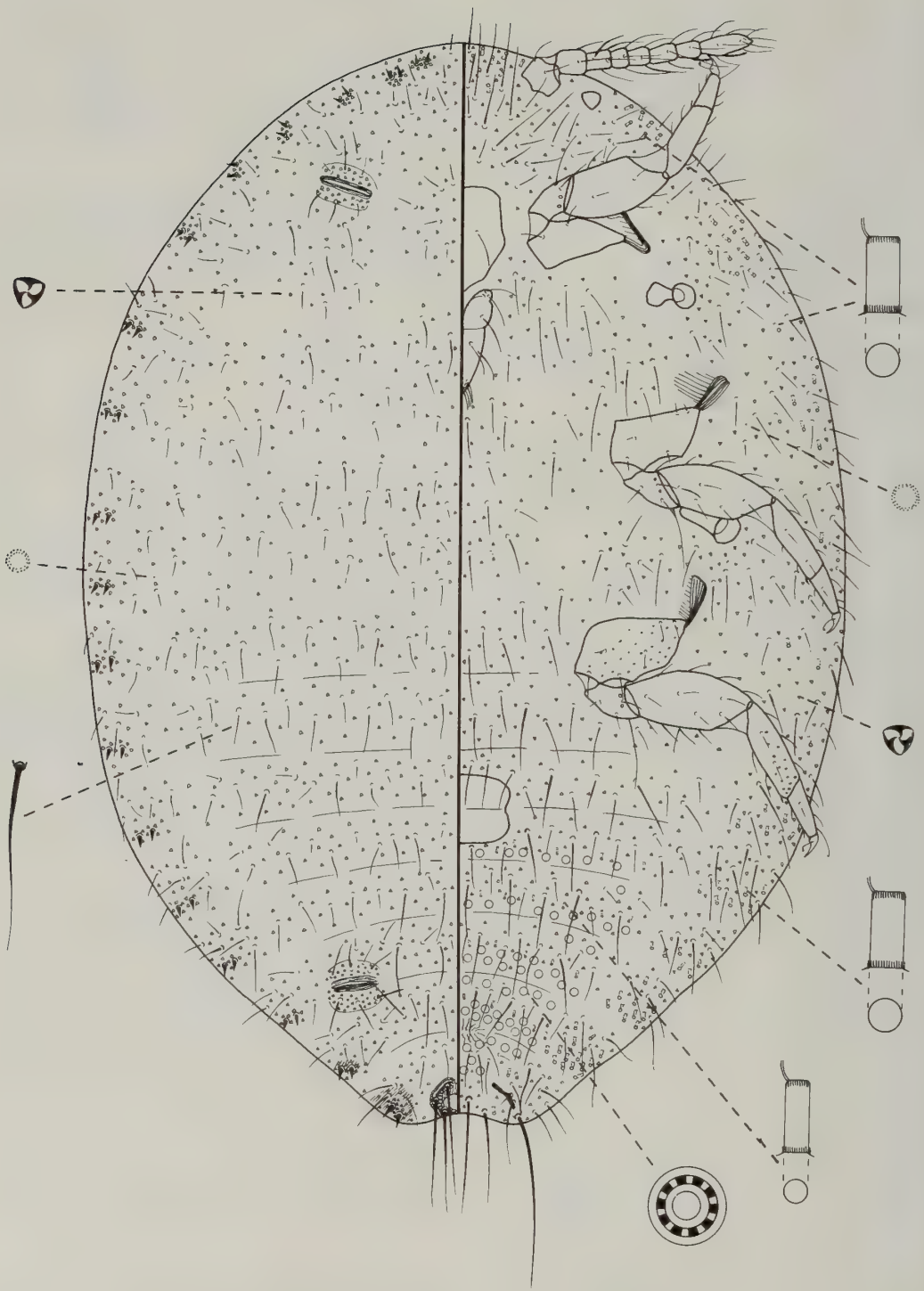

Fig. 22 *Planococcus lilacinus* (Cockerell).

slender setae. Legs stout; hind trochanter + femur 210–315 μm long, hind tibia + tarsus 210–275 μm long, ratios of lengths of hind tibia + tarsus to hind trochanter + femur 0.77–0.97; translucent pores present on hind coxae and tibiae. Inner edges of ostioles strongly sclerotized. Circulus large and quadrate, width 105–200 μm. Cisanal setae noticeably longer than anal ring setae. Anal lobe cerarii each situated on a moderately sized, well-sclerotized area.

Venter. Multilocular disc pores occurring on median areas only, present around vulva, in single or double rows across posterior borders of median areas of abdominal segments IV-VII and usually in a single row across anterior edge of segment VII (although the latter is sometimes reduced to a few pores), and a few pores sometimes present on anterior edges of median areas of abdominal segments V and VI. Trilocular pores moderately numerous and evenly distributed. Oral collar tubular ducts of 2 sizes; smaller ducts occurring sparsely in rows across median areas of abdominal segments III-VII; larger ducts sparsely scattered over median areas of thorax and present in marginal groups around entire venter, a few ducts also present adjacent to each postocular cerarius. Simple pores about the same size as the trilocular pores, sparsely but evenly distributed.

Dorsum. Multilocular disc pores and tubular ducts absent. Trilocular pores as for venter. Simple pores smaller than the trilocular pores, sparsely but evenly distributed. Setae very long, stout and flagellate, length of longest seta on abdominal segments VI or VII 50–140 μm.

MATERIAL EXAMINED

About 200 ♀ (including type material listed below) (BMNH, USNM).

Pseudococcus lilacinus Cockerell. 8 syntype ♀, **Philippines:** Lucan, Tayabas, on orange (cult.), 10.iv.1904 (*Townsend*) (USNM).

Pseudococcus tayabanus Cockerell. 4 syntype ♀, **Philippines:** Lucban, Tay[abas], 7 20.iv.1904 (*Townsend*) (USNM).

Tylococcus mauritiensis Mamet. 8 paratype ♀, **Mauritius:** Corpes de Garde Mt, on *Eugenia mespiloides*, 30.i.1938 (*R. Mamet*) (BMNH).

Pseudococcus crotonis Green, 4 syntype ♀, **Sri Lanka (Ceylon):** Gammaduwa, on *Castilloa* [= *Castilla*] *elastica* (*E. E. Green*) (BMNH).

DISTRIBUTION. Palaearctic Region: Aden. Malagasian Region: Madagascar, Mauritius, Seychelles. Oriental Region: Bangladesh, Burma, China, Formosa, India, Sri Lanka, Vietnam. Austro-oriental Region: Borneo, Indonesia, West Malayasia, Papua New Guinea, Philippines, Java, Cocos Keeling Island. Neotropical Region: Guyana.

HOSTPLANTS. Anacardaceae: *Mangifera indica*. Annonaneae: *Annona* sp., *Cananga odorata*. Asteraceae: *Adenophyllum* sp. Bombaceae: *Ochroma* sp. Dioscoreaceae: *Dioscorea* sp. Dipterocarpaceae: *Dipterocarpus* sp. Ehretiaceae: *Cordia myxa*. Euphorbiaceae: *Codiaeum* sp., *Euphorbia pyrifolia, Mallotus japonicus*. *Iridaceae: Gladiolus carmels*. Lecythidaceae: *Couroupita guianensis*. Leguminosae: *Albizia lebbeck, Arachis hypogea, Bauhinia monandra, Cajanus* sp., *Erythrina lithosperma, E. variegata, Hymenaea* sp., *Prosopsis juliflora, Tamarindus indica*. Moraceae: *Castilloa elastica, Ficus rubra*. Myrtaceae: *Eugenia mespiloides, Psidium guava*. Palmae: *Cocos nucifera, Phoenix dactylifera*. Pandaceae: *Pandanus* sp. Puniaceae: *Punica granatum*. Rhamnaceae: *Alphitonia incana, Zizyphus jujuba*. Rubiaceae: *Coffea canephora, C. sepahijala*. Rutaceae: *Citrus aurantium, C. grandis*. Sapindaceae: *Litchi* sp. Simaroubaceae: *Ailanthus* sp. Solanaceae: *Nicotiana tabacum*. Sterculiaceae: *Theobroma cacao*. Umbelliferae: *Apium graveolens*. Verbenaceae: *Tectona grandis*. Vitidaceae: *Vitis vinifera*.

REMARKS. The combination of stout legs, long dorsal setae and reduced numbers of multilocular disc pores distinguishes this species from the other known species of *Planococcus*. Some variation occurs in the thickness of the anterior cerarian setae; usually these are moderately stout and conical, but some specimens, notably those from Aden, have some of these setae long and flagellate.

Avasti & Shafee (1987: 38) described a new species, *Planococcus indicus*, from India on a wild plant. Although no type material has been examined, from the original description and illustration it seems likely that *P. indicus* is conspecific with *P. lilacinus*.

In the 1920s and 1930s the African species *P. kenyae* was frequently misidentified as *P. lilacinus*, but the latter is not, as yet, known from this continent. The phylogenetic relationships of *P. lilacinus* are obscure; it does not seem to fit into any of the species-groups into which *Planococcus* has been divided here.

ECONOMIC STATUS. *P. lilacinus* is a pest of cocoa throughout the Oriental Region and also occurs on a wide variety of economically important crops such as *Citrus*, guava, coffee, custard apple and mango. Le Pelley (1943b) discusses the hostplants, biology and natural enemies of this species in some detail.

Planococcus litchi sp. n.

(Fig. 23)

ADULT FEMALE. Mounted specimens oval, length 1.3–2.7 mm, width 0.7–2.0 mm. Margin of body with a complete series of 18 distinct pairs of cerarii, each cerarius with 2 conical setae except for the preocular and postocular cerarii each with 1–3 setae, all cerarian setae elongate-conical and with flagellate tips. Legs elongate; hind trochanter + femur 240–325 μm long, hind tibia tarsus 270–345 μm long; ratios of lengths of hind tibia + tarsus to hind trochanter + femur 1.07–1.16; translucent pores visible on hind coxae and tibiae. Inner edges of ostioles lightly sclerotized. Circulus quadrate and of moderate size, width 95–165 μm. Cisanal setae shorter than anal ring setae. Anal lobe cerarii each situated on a small, moderately sclerotized area.

Venter. Multilocular disc pores confined to median areas of body, present around vulva, in single rows (sometimes double on segment VII in larger specimens) across posterior edges of abdominal segments III-VII (sometimes 1 or 2 pores also on segment II) and anterior edge of abdominal segment VII (sometimes 1–4 pores also present on anterior border of segment VI and occasionally a single pore present on anterior border of segment V); a few pores scattered over thorax. Trilocular pores somewhat sparse. Oral collar tubular ducts of 2 sizes; smaller size present in rows across median areas of abdominal segments VI or VII; larger size present in rows across abdominal segments III-V, scattered over median areas of thorax and occurring in groups around entire venter, but usually absent, or at most 1 duct adjacent to each postocular cerarius. Simple pores about half the size of the trilocular pores, sparsely scattered over entire venter.

Dorsum. Multilocular disc pores absent. Trilocular pores moderately numerous and aggregated around bases of enlarged setae. Tubular ducts, larger than the larger ducts on the venter and without apparent rims, sometimes present singly next to some abdominal cerarii and submedially on some abdominal and thoracic segments, up to 11 ducts present, but frequently absent. Simple pores as for venter but very sparse. Dorsal setae of various sizes, larger setae elongate-conical and with flagellate apices, about the same size as the cerarian setae and each with 2–4 trilocular pores associated with their bases giving the appearance of dorsal cerarii, these enlarged setae present on all body segments except the last abdominal segment; several enlarged setae associated in pairs, submedially and medially on the thorax, and medially on adbominal segment VII; length of longest seta on abdominal segments VI or VII 25–30 μm.

MATERIAL EXAMINED

Holotype ♀, **Hong Kong** (intercepted at Heathrow, U.K.): on lychees, 1980 (no collector) (BMNH).

Paratypes. **Japan** (intercepted in Hawaii): 1 ♀, on fruit of *Litchi* sp., 17.v.1959 (*R. O. Parsons*) (USNM). **Philippines** (intercepted at San Francisco): 6 ♀, on *Litchi chinensis* fruit, 26.v.1972 (*E. Roberts*) (USNM). **Thailand:** 1 ♀ (intercepted in U.S.A.), on *Litchi* sp. (fruit), 29.vi.1980 (*L. Roberson*) (USNM); 2 ♀ (intercepted in England), on lychees, 1984 (BMNH); 1 ♀ (intercepted in U.S.A.), on *Eriobotrya japonica* (fruit), 6.viii.1982 (*B. Stephenson*) (USNM). **Hong Kong:** 10 ♀ (intercepted at Seattle), on *Litchi* sp. (fruit), 30.v.1976 (*C. R. Payne*) (USNM); 1 ♀ (intercepted at Seattle), on *Litchi chinensis* (fruit), 22.viii.1974 (*R. F. Goodall, M. Harris*) (USNM); 1 ♀ (intercepted?), on litchi, 10.viii.1961 (*R. T. Mitsude*) (USNM). China (intercepted at Seattle): 3 ♀, on litchi (twigs and fruit), 22.v.1960 (*H. C. Nelson*) (USNM).

DISTRIBUTION. Palaearctic Region: Japan. Oriental Region: China, Hongkong, Thailand. Austro-oriental Region: Philippines. All of these records are based on interceptions in either the U.K. or the U.S.A.

HOSTPLANTS. Rosaceae: *Eriobotrya japonica.* Sapindaceae: *Litchi chinensis*. Most commonly found on lychees.

REMARKS. The enlarged dorsal setae with trilocular pores aggregated around their bases indicate that this species is a member of the *P. dorsospinosus*-group. It may be distinguished from the other 2 known species of this group, *P. dioscoreae* and *P. dorsospinosus*, by the larger size and grouping of the enlarged dorsal setae into several pairs.

ECONOMIC STATUS. *P. litchi* is frequently intercepted on lychee fruit imported into the U.S.A. and the U.K.

Planococcus mali Ezzat & McConnell

(Fig. 24)

Planococcus mali Ezzat & McConnell, 1956: 93; Williams, 1985: 274; Cox, 1987: 75. Holotype ♀, NEW ZEALAND (intercepted in U.S.A.): on *Olearia chathamica* (USNM) [examined].

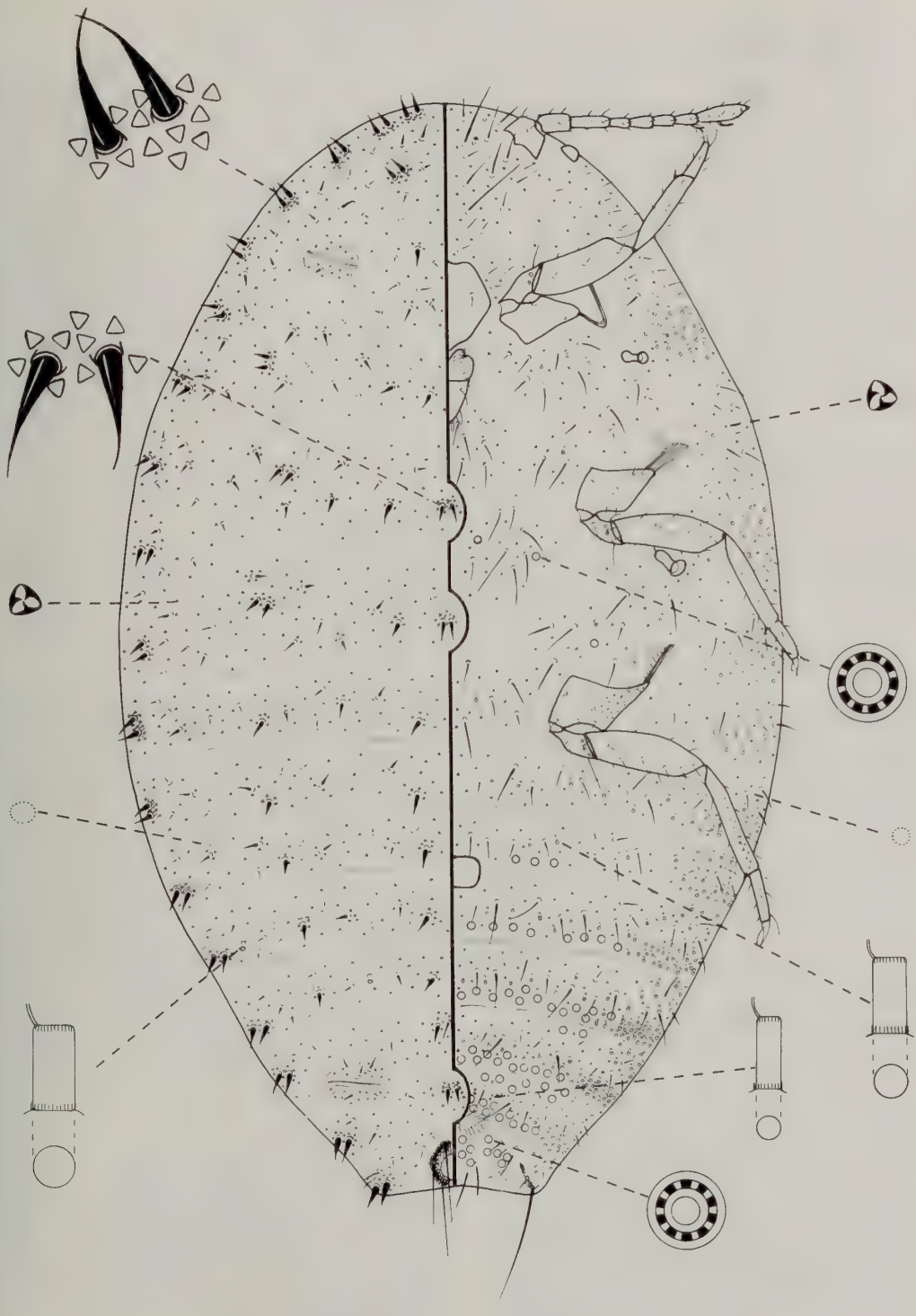

Fig. 23 *Planococcus litchi* sp. n.

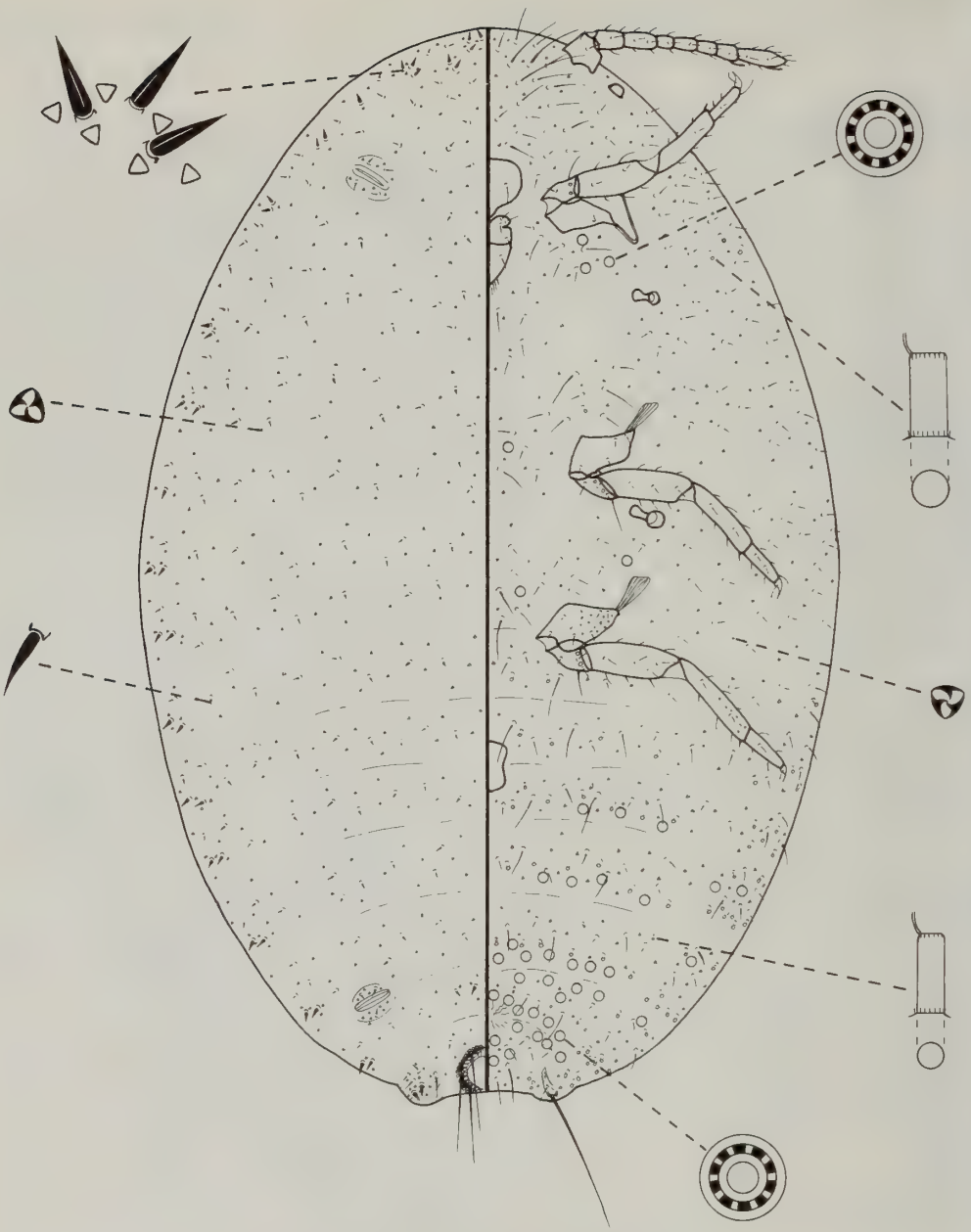

Fig. 24 *Planococcus mali* Ezzat & McConnell.

ADULT FEMALE. Mounted specimens oval, length 2.3–3.3 mm, width 1.2–2.0 mm. Margin of body usually with a complete series of 18 pairs of cerarii, although some pairs are often indistinct or even absent, cephalic and thoracic pairs each with 2–5 conical setae and abdominal pairs each with 2 conical setae. Legs elongate, hind femur + trochanter 275–380 μm long, hind tibia + tarsus 305–410 μm long, ratio of lengths of hind tibia + tarsus to hind trochanter + femur 1.03–1.17; translucent pores present on hind coxae and tibiae. Inner edges of ostioles lightly sclerotized. Circulus quadrate, width 80–190 μm. Cisanal setae shorter than anal ring setae. Anal lobe cerarii each situated on a small, moderately sized, moderately sclerotized area.

Venter. Multilocular disc pores situated around vulva, in rows across posterior edges of median

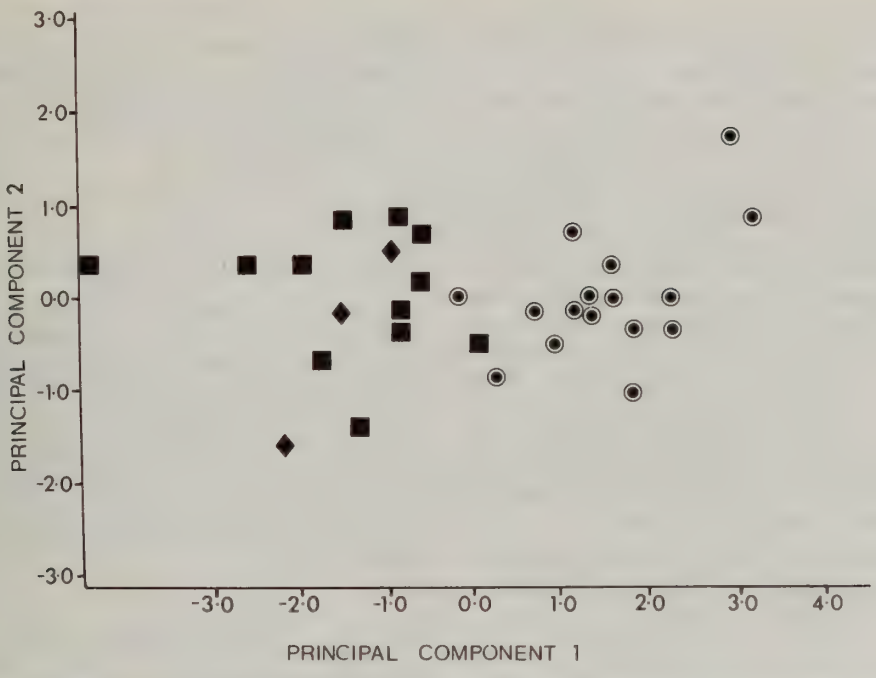

Fig. 25 Plot of first against second principal components of material of *japonicus/mali* from different countries. Squares, New Zealand; diamonds, Australia; circles, Japan.

areas of abdominal segments III-VII or IV-VII and across anterior edges of segments V-VII or VI VII, a few pores present on margins of segments V-VII or VI or VII, a single pore sometimes situated on head, 0–22 pores scattered over median areas of thorax, and in larger specimens, up to 7 pores present amongst the tubular ducts grouped on each side of the prothorax. Trilocular pores evenly distributed. Oral collar tubular ducts of 2 sizes; smaller ducts in rows across median areas of abdominal segments II-VII; larger ducts in rows across median areas of segments IV-VI, in marginal groups on segments I-VIII, sometimes in a marginal group on each side of prothorax, and sometimes present in small numbers on head and margins of mesothorax. Simple pores not apparent.

Dorsum. Multilocular disc pores and tubular ducts absent. Trilocular pores and simple pores as for venter. Setae short and stout, sometimes almost conical, longest seta on abdominal segments VI or VII 15–20 μm long.

MATERIAL EXAMINED

20 ♀ (including type material listed below) (BMNH, NZAC, USNM).

Holotype ♀, **New Zealand** (intercepted at Honolulu): on *Olearia chathamica*, 21.ix.1937 (USNM). Paratypes, 1 ♀, same data as holotype. **Australia:** 1 ♀, Tasmania (intercepted at Buffalo, New York), on *Pyrus malus* [*Malus pumila*], 26.vi.1946 (*Inman Reeges*); 1 ♀, same locality and host (intercepted at Boston, Massachusetts), 27.vi.1946 (USNM).

DISTRIBUTION. Australian Region: Tasmania. New Zealand Region: New Zealand. Also recorded by Williams (1985) from New South Wales.

HOSTPLANTS. Asteraceae: *Olearia chathamica*. Grossulariaceae: *Ribes nigrum*. Labiatae: *Phlomis* sp. Leguminosae: *Acacia* sp. *A. verheillata, Ulex* sp. Pittosporaceae: *Pittosporum* sp. Primulariaceae: *Primula* sp. Rosaceae: *Cotoneaster* sp., *Malus pumila*. Also recorded by Williams (1985) from *Acacia longifolia* and *Psoralea pinnata* (Leguminosae), and *Callitris tasmanica* (Cupressaceae).

REMARKS. *P. mali* is so similar to *P. japonicus* that a principal components analysis was carried out to confirm their distinction (Fig. 25). The two species differ primarily by the fewer tubular ducts in the prothoracic groups and larger legs of *P. mali*. This species is very variable, however, and large specimens may also have large groups of ducts on

the prothorax. These specimens usually also have multilocular disc pores in these groups, a feature never found in *P. japonicus*.

It seems unlikely that sister-species should occur in Japan and New Zealand/Australia respectively. A possible explanation for this is that *P. mali* has been introduced into New Zealand and Australia from somewhere in the vicinity of Japan. This theory is supported by its host preferences in New Zealand and Australia; it occurs most commonly on introduced northern-temperate plants such as *Ribes* and *Malus*, and is, in fact, a pest of blackcurrant in New Zealand. Extensive collecting in Japan may reveal a complex of species. The lack of records of this species from Japan, if it does indeed occur there, might seem surprising at first, but it is possible that this species has been misidentified as *Crisicoccus azaleae*. This is discussed further under *P. japonicus*.

ECONOMIC STATUS. *P. mali* is a pest of blackcurrants in New Zealand.

Planococcus martini sp. n.

(Fig. 26)

ADULT FEMALE. Mounted specimens broadly oval to rotund, length 1.9–2.8 mm, width 1.4–2.1 mm. Margin of body with a complete series of 18 distinct pairs of cerarii, each cerarius with 2 conical setae. Antennae 7-segmented. Legs somewhat stout; hind trochanter + femur 200–230 μm long, hind tibia + tarsus 185–220 μm long, ratio of lengths of hind tibia + tarsus to hind trochanter + femur 0.91–0.96; translucent pores present on hind coxae and a few barely apparent on hind tibiae. Inner edges of ostioles barely sclerotized. Circulus oval, width 70–105 μm. Cisanal setae shorter than anal ring setae. Anal lobe cerarii each situated on a fairly prominent sclerotized area.

Venter. Multilocular disc pores confined to median areas, present around vulva and in single rows across posterior edges of abdominal segments V or VI, sometimes also IV. Trilocular pores somewhat sparse. Oral collar tubular ducts of one size, present in rows across median areas of abdominal segments VI or VII, usually also V. Simple pores about the same size as the trilocular pores, sparsely scattered over entire venter.

Dorsum. Multilocular disc pores and tubular ducts absent. Trilocular pores moderately numerous and evenly distributed. Simple pores about half the size of the trilocular pores, sparsely scattered over dorsum. Setae short and stout, length of longest seta on abdominal segments VI or VII 16–25 μm.

MATERIAL EXAMINED

Holotype ♀, **Indonesia:** Sulawesi Utara, nr Base Camp Toraut, roots of Araceae, ?Epipremnum sp., 5.iii.1985 (*J. H. Martin*) (BMNH).

Paratypes. 19 ♀, same data as holotype (BMNH, USNM).

DISTRIBUTION. Austro-oriental Region: Indonesia.

HOSTPLANTS. Araceae: ?*Epipremnum* sp.

REMARKS. This species is most similar to the *dendrobii*-group by virtue of its rotund body and in having the multilocular disc pores and oral collar tubular ducts confined to the abdomen. It differs from this group by having 7-segmented antennae and by lacking knobbed dorsal setae, and from the similar *P. zairensis* by having groups of tubular ducts present on, but multilocular disc pores absent from, the margins of abdominal segments VI VII.

Planococcus minor (Maskell) nom. rev., stat. n., comb. n.

(Fig. 27)

Pseudococcus calceolariae var. *minor* Maskell, 1897: 322. LECTOTYPE ♀, MAURITIUS: on roots of 'onion grass' (NZAC) here designated [examined].

Planococcus pacificus Cox, 1981: 48. Holotype ♀, WESTERN SAMOA (intercepted in quarantine, Auckland, New Zealand): on croton leaves (BMNH) [examined]. **Syn. n.**

ADULT FEMALE. Mounted specimens oval, length 1.3–3.2 mm, width 0.8–1.9 mm. Margin of body with complete series of 18 pairs of cerarii, each cerarius with 2 conical setae, except for preocular cerarii each of which may have 1 or 3 setae. Legs elongate; hind trochanter + femur 220–360 μm long, hind tibia + tarsus 270–360 μm long, ratio of lengths of hind tibia + tarsus to hind trochanter + femur 1.05–1.15; translucent pores apparent on hind coxae and tibiae. Inner edges of ostioles moderately sclerotized. Circulus quadrate, width 85–160 μm. Cisanal setae usually shorter than anal ring setae, occasionally longer. Anal lobe cerarii each situated on a small, moderately sclerotized area.

Venter. Multilocular disc pores present around vulva, in double rows across posterior edges of abdominal segments III-VII (except in very small specimens, hind tibia tarsus less than 250 μm, where these rows may be single), in single rows across anterior edges of segments V-VII or VI-VII, in small groups on margins of abdominal

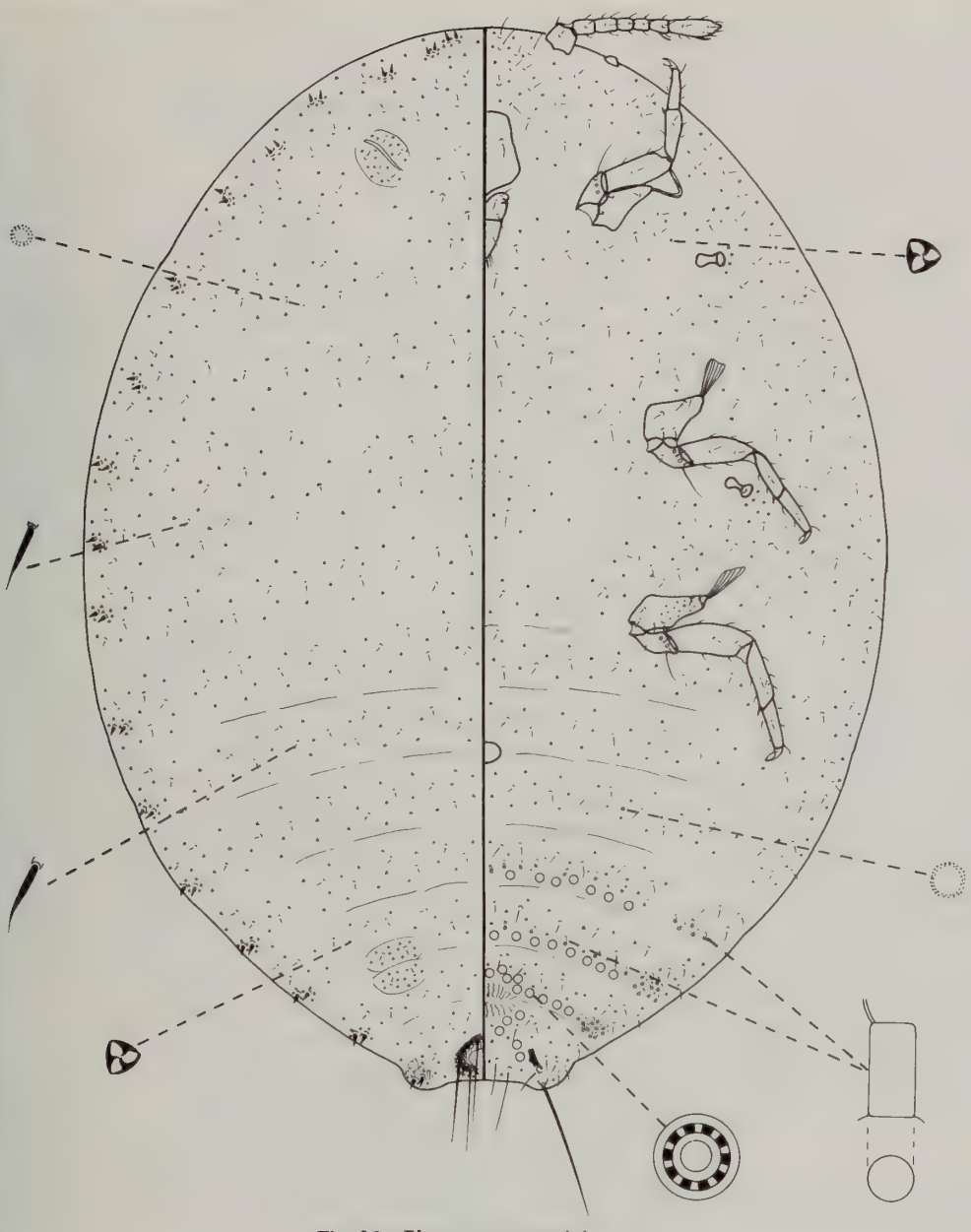

Fig. 26 *Planococcus martini* sp. n.

segments IV-VII, sometimes a few pores scattered over median area of the thorax and head, and frequently several pores present behind each front coxa. Trilocular pores moderately numerous and evenly distributed. Oral collar tubular ducts of 2 sizes; smaller ducts present sparsely in rows across median areas of abdominal segments III-VII; larger ducts present in marginal groups on abdominal segments, often present in small numbers on margins of head and thoracic segments (see Table 1), and scattered over median area of thorax. Simple pores about the same size as the trilocular pores, sparsely but evenly distributed.

Dorsum. Multilocular disc pores absent. Tubular ducts, without apparent rims and slightly larger than the larger size on the venter, sometimes present adjacent to some cerarii, 1 or 2 ducts occasionally present on median areas. Trilocular pores as for venter. Simple pores of 2 sizes, smaller pores smaller than those on venter, scattered over

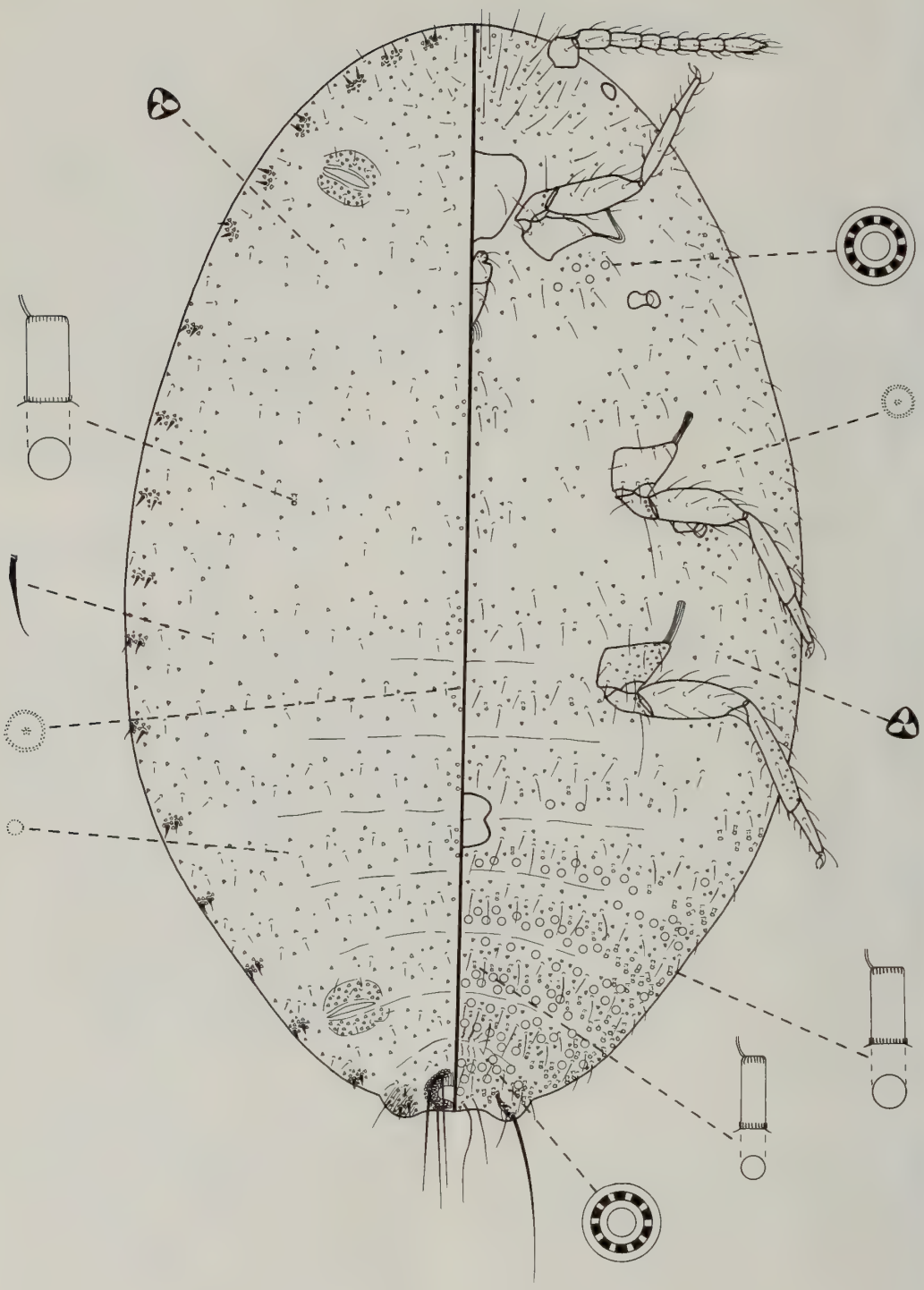

Fig. 27 *Planococcus minor* (Maskell).

dorsum; larger pores about twice the size of the trilocular pores, present in small groups along midline of thoracic and anterior abdominal segments. Setae flagellate and of moderate length, longest seta on abdominal segment VI or VII 25–30 μm long.

MATERIAL EXAMINED

Over 200 ♀ (including type material listed below) (BMNH, NZAC).

Dactylopius calceolariae var. *minor* Maskell. Lectotype ♀ here designated, on slide labelled: 'Dactylopius calceolariae var. minor, adult female, 1896, W. M. M.' (NZAC).

Planococcus pacificus Cox. Holotype ♀, **Western Samoa** (intercepted at Auckland, New Zealand): on croton leaves, 10.v.1979 (*C. Butcher*) (BMNH). 385 paratype ♀, reared from holotype in England, on potato tubers at various temperatures, 18.vi.1979–30.viii.1979 (*J. M. Cox*) (BMNH, NZAC, USNM).

DISTRIBUTION. Oriental Region: Bangladesh, Chagos Arch., Burma, India, Rodrigues I., Seychelles Is, Thailand. Austro-oriental Region: Borneo, West Malaysia, Papua New Guinea, Philippines, Singapore, Sumatra. Australian Region: New South Wales, Northern Territory, Queensland, South Australia. Polynesian Region: Solomon Islands, Austral Islands, Cook Islands, American Samoa, Fiji, Kiribati, Niue, Society Islands, Tokelau, Tonga, Tuvalu, Vanuatu, Western Samoa. Neotropical Region: Barbados, Ecuador, Grenada, Jamaica, Trinidad, St Lucia, Virgin Islands. Malagasian Region: Madagascar, Mauritius.

HOSTPLANTS. Acanthaceae: *Pachystachys coccineae.* Agavaceae: *Furcraea gigantea.* Amaranthaceae: *Celosia* sp. Annonaceae: *Annona muricata.* Araceae: *Anthurium* sp., *Colocasia antiquorum, Dieffenbachia* sp. *Pistia stratiotes, Xanthosoma sagittifolium.* Asclepiadaceae: *Hoya* sp. Asteraceae: *Emilia sonifolia.* Cactaceae: *Harrisia portaricensis.* Cannaceae: *Canna* sp. Cucurbitaceae: *Luffa actangula.* Ebenaceae: *Diospyros discolor.* Ehretiaceae: *Cordia myxa.* Euphorbiaceae: *Alcalypha hispida, Cassava utilissima, Codiaeum variegatum Croton* sp. Geraniaceae: *Geranium* sp. Labiatae: *Epimeredi indicus, Ocimum sanctum.* Leguminosae: *Gliricidia maculata, Glycine max, Psophocarpus tetragonolobus, Tephrosia* sp. Liliaceae: *Asparagus* sp. Malvaceae: *Gossypium* sp. Marantaceae: *Maranta* sp. Moraceae: *Artocarpus communis, Ficus elastica.* Musaceae: *Musa sapientum.* Myrtaceae: *Psidium guajava.* Nyctaginaceae: *Boerhavia diffusa.* Palmae: *Chrysalidocarps* sp., *Howeia forsteriana.* Passifloraceae: *Passiflora edulis.* Periplocaceae: *Mondia citrifolia.* Piperaceae: *Piper nigrum.* Poaceae: *Bambusa* sp., *Orya sativa.* Polygonaceae: *Rumex* sp. Rosaceae: *Fragaria* sp. Rubiaceae: *Coffea arabica, C. liberica, C. robusta, Randia heterophylla.* Rutaceae: *Choisya* sp. Sapindaceae: *Nephelium lappaceum.* Sapotaceae: *Manilkara zapota.* Solanaceae: *Lycopersicon esculentum, Solanum grandiflorum, S. torrum, S. tuberosum.* Sterculiaceae: *Theobroma cacao.* Thunbergiaceae: *Thunbergia* sp. Verbenaceae: *Clerodendrum thompsonae, Verbena* sp. Many further host plants are listed by Williams (1982) under *P. pacificus*.

REMARKS. *Dactylopius calceolariae* var. *minor* was synonymized with *Planococcus citri* by Morrison (1925). The type material of the former taxon, however, although poor, appears to be the same species as that described as *P. pacificus* by Cox (1981). Additional evidence lies in the fact that no specimens of *P. citri* from the Malagasian Region were encountered during this study.

P. minor is very similar to *P. citri*, and the existence of the second species was not established until the variation of individual populations was studied using rearing experiments by Cox (1981, 1983) (see also under Introduction).

Although *P. citri* has frequently been recorded from the South Pacific Islands, Williams (1982) comments that most of these records are misidentifications of *P. minor*. His records show *P. minor* to be much more common than *P. citri* in this area, and to have been substantially longer established, the earliest record given of *P. citri* from the area being 1975 and that of *P. minor*, 1922

Likewise, Cox & Freeston (1985) showed that the species of *Planococcus* commonly occurring on *Theobroma cacao* in the Oriental and Neotropical Regions was in fact *P. minor* and not *P. citri*, although most published records are under the latter name.

ECONOMIC STATUS. *P. minor* is a common species on many economically important plants, particularly cocoa, throughout its geographical range.

Planococcus morrisoni (Ezzat & McConnell)

(Fig. 28)

Allococcus morrisoni Ezzat & McConnell, 1956: 17. Holotype ♀, PHILIPPINES: on *Lansium domesticum* (USNM) [examined].

Planococcus morrisoni (Ezzat & McConnell) Cox & Ben-Dov, 1986: 488.

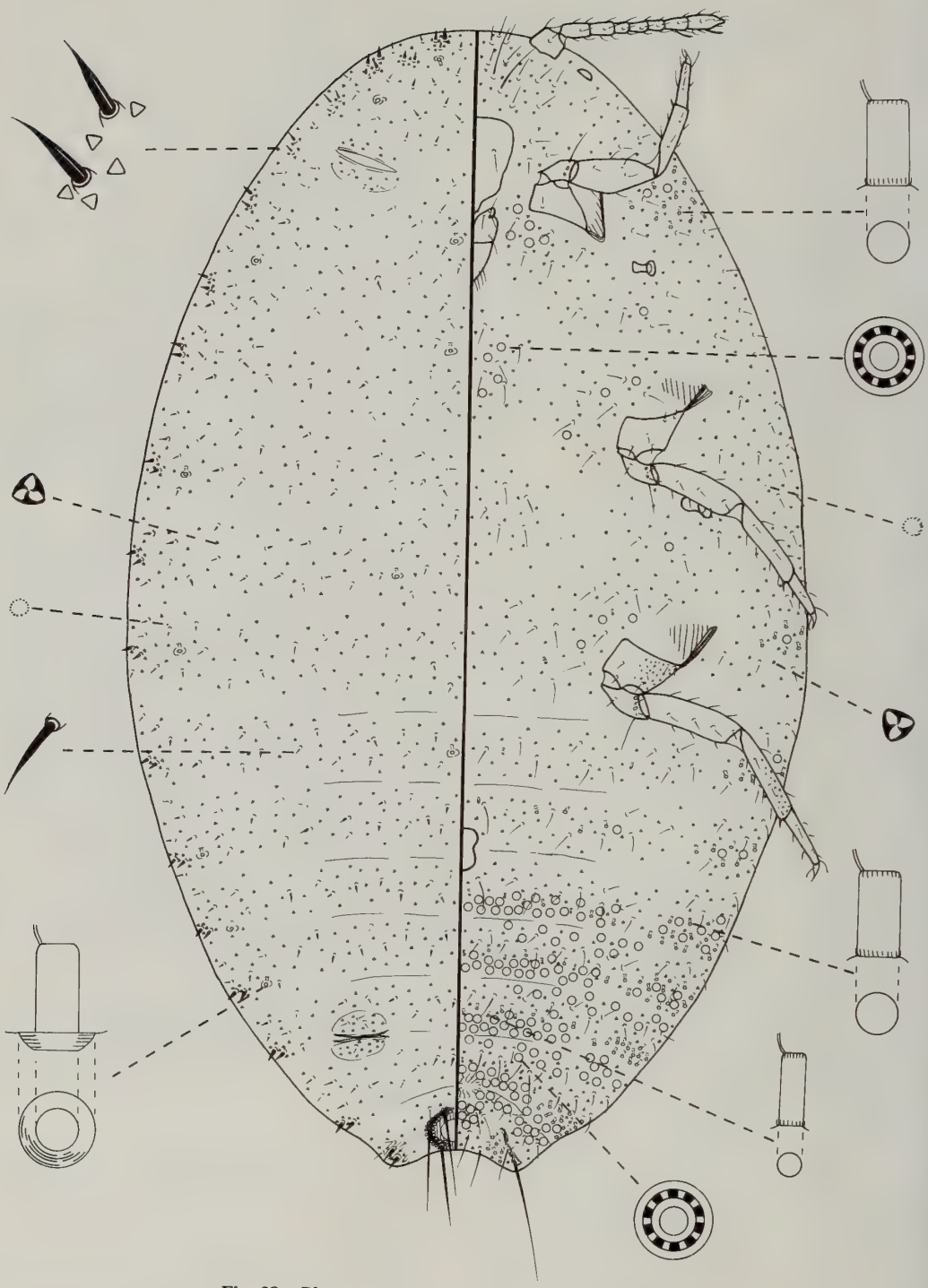

Fig. 28 *Planococcus morrisoni* (Ezzat & McConnell)

ADULT FEMALE. Mounted specimens elongate-oval, length 1.4–2.4 mm, width 0.6–1.3 mm. Margin of body with complete series of 18 pairs of cerarii, each cerarius with 2 slender conical setae, except for head and thorax where some cerarii may be indistinct and others with up to 4 conical setae. Legs elongate; hind trochanter + femur 210–285 μm long, hind tibia + tarsus 230–295 μm long, ratio of lengths of hind tibia + tarsus to hind trochanter + femur 1.04–1.09; translucent pores apparent on hind coxae and tibiae. Inner edges of ostioles only slightly sclerotized. Circulus quadrate, width 40–115 μm. Cisanal setae shorter than anal ring setae. Anal lobe cerarii situated on small, moderately sclerotized areas.

Venter. Multilocular disc pores present around vulva, in double rows across posterior edges of abdominal segments IV-VII and sometimes in a single row on segment III, scattered over anterior edges of segments V-VII; also present in small groups on margins of adominal segments I-VIII and scattered over median area of the thorax. Trilocular pores moderately numerous and evenly distributed. Oral collar tubular ducts of 2 sizes; smaller ducts present sparsely in rows across median areas of abdominal segments IV-VII and scattered over median areas of thorax; larger size present sparsely in rows across median areas of abdominal segments III-VI, and in marginal groups on segments I-VIII and on prothorax adjacent to front coxae. Simple pores considerably smaller than the trilocular pores, sparsely scattered over venter.

Dorsum. Multilocular disc pores ducts absent. Tubular ducts, larger than the larger size on the venter and with distinct rims, present singly next to some cerarii and sparsely scattered over median areas. Trilocular pores and simple pores as for venter. Setae short and stout, almost lanceolate, longest seta on abdominal segments VI or VII 10–20 μm long.

MATERIAL EXAMINED

9 ♀ (including type material listed below) (BMNH, USNM).

Holotype ♀, **Philippines**, on *Lansium domesticum*, 30.viii.1951 (*R. O. Parsons*) (USNM).

DISTRIBUTION. Oriental Region: Thailand. Austro-oriental Region: Philippines, West Malaysia. All of these records are based on interceptions in the U.S.A.

HOSTPLANTS. Clusiaceae: *Garcinia mangostana*. Meliaceae: *Lansium domesticum*. Sapindaceae: *Litchi chinensis, Melicoccus bijugatus*.

REMARKS. The presence of marginal multilocular disc pores, short, stout, almost lancolate, dorsal setae, and a group of tubular ducts adjacent to each anterior coxa, whilst these ducts are absent from the head, show this species to be allied to *P. mali*. The large tubular ducts with pronounced oral rims, however, clearly distinguish *P. morrisoni*.

ECONOMIC STATUS. This species is frequently intercepted on fruit entering the U.S.A.

Planococcus nigritulus De Lotto
(Fig. 29)

Planococcus nigritulus De Lotto, 1961: 222. Holotype ♀, ZAIRE: on *Phoenix 'canariensis'* (given as *dactylifera* on the label) (BMNH) [examined].

ADULT FEMALE. Mounted specimens oval to rotund, length 1.9–2.4 mm, width 1.3–1.8 mm. Margin of body with complete series of 18 pairs of cerarii, each cerarius with 2 moderately stout conical setae. Legs somewhat stout; hind trochanter + femur 255–285 μm long, hind tibia + tarsus 245–275 μm long, ratio of lengths of hind tibia + tarsus to hind trochanter + femur 0.93–1.10; translucent pores present on hind coxae and tibiae. Inner edges of lips of ostioles not noticeably sclerotized. Circulus large and quadrate, width 130–190 μm. Cisanal setae longer than anal ring setae. Anal lobe cerarii each situated on a very small, lightly sclerotized area.

Venter. Multilocular disc pores present around vulva, in rows across posterior edges of median areas of abdominal segments IV-VII and across anterior edges of segments VI or VII, and present in small marginal groups on segments IV-VII. Trilocular pores numerous and evenly distributed. Oral collar tubular ducts of 2 sizes; smaller ducts present in rows across median areas of abdominal segments V-VII; larger ducts occurring in rows across median areas of abdominal segments IV V and in marginal groups around entire venter except for abdominal segments VIII or IX from which they are entirely absent. Simple pores about twice the size of the trilocular pores, scattered over entire venter.

Dorsum. Multilocular disc pores and tubular ducts absent. Trilocular pores as for venter. Simple pores of 2 sizes, larger pores the same size as those on the venter, in median groups on thoracic and anterior abdominal segments and scattered sparsely over thorax, smaller size slightly smaller than the trilocular pores, scattered over the abdominal segments. Setae flagellate, stout and moderately long, longest seta on abdominal segments VI or VII 25–40 μm long.

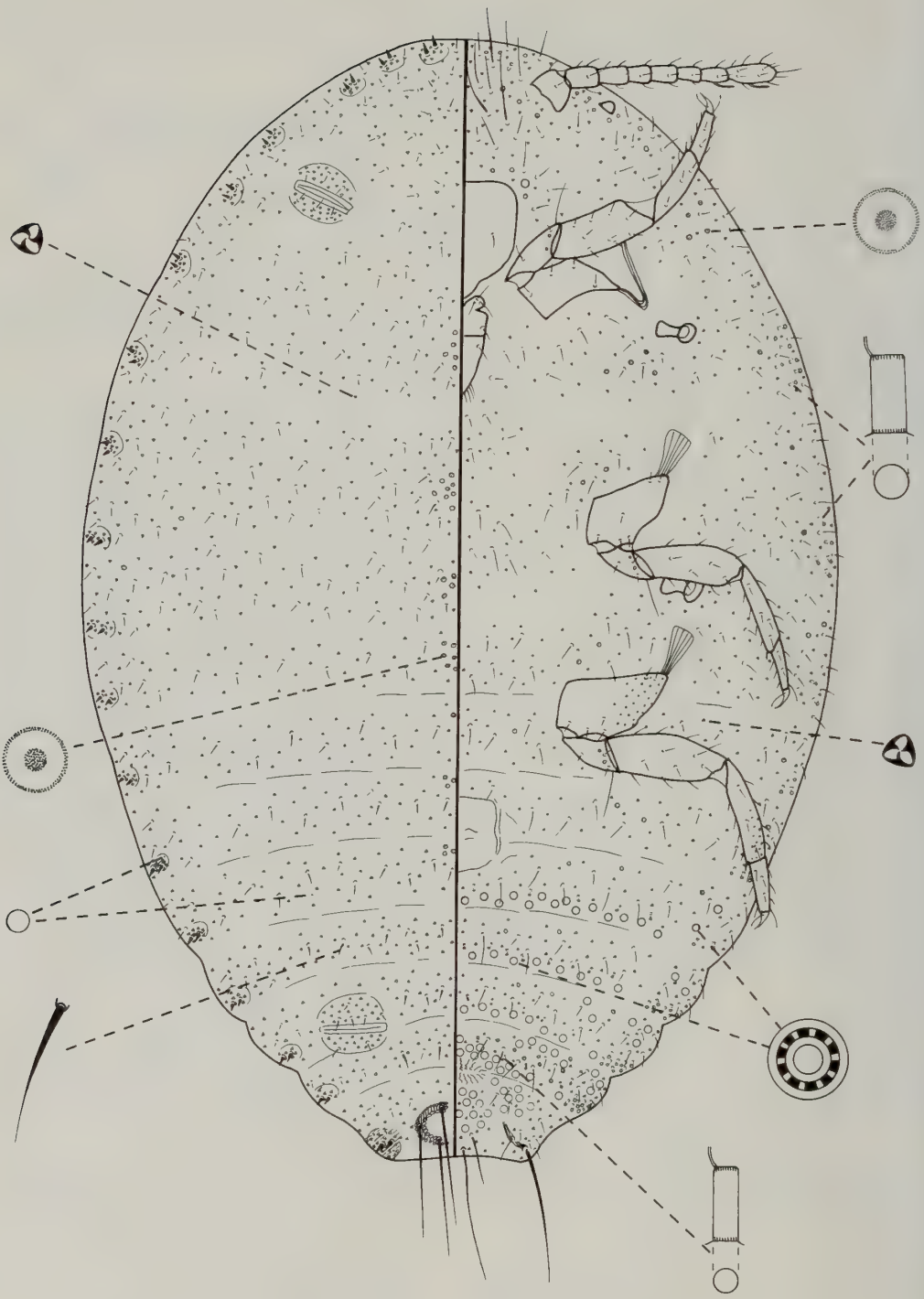

Fig. 29 *Planococcus nigritulus* De Lotto.

MATERIAL EXAMINED

Holotype ♀, **Zaire** (Belgian Congo): Katana, on *Phoenix dactylifera*, 15.x.1941 (*F. Hendrick*) (BMNH). 11 paratype ♀, same data as holotype (BMNH). The host is given as *P. canariensis* in the original description.

DISTRIBUTION. Afrotropical Region: Zaire. Also recorded from Tanzania (as Tanganyika) (De Lotto, 1964).

HOSTPLANTS. Palmae: *Phoenix dactylifera*. Also recorded from *Ficus* sp. (Moraceae) (De Lotto, 1964).

REMARKS. *P. nigritulus* is similar to *P. aemulor* and *P. tanzaniensis* in its rotund body shape, stout, almost fleshy, dorsal setae, large ventral simple pores, and absence of oral rim tubular ducts from abdominal segment IX. Unlike *P. nigritulus, P. aemulor* lacks both translucent pores on the hind legs and marginal tubular ducts on the venter. *P. tanzaniensis* possesses tubular ducts on the median areas of the thorax; these are absent in *P. nigritulus*.

Planococcus orchidi sp. n.

(Fig. 30)

ADULT FEMALE. Mounted specimens broadly oval to rotund, length 1.1–2.0 mm, width 1.0–1.5 mm. Margin of body with a complete series of 18 pairs of cerarii, each with 2 stout conical setae. Legs stout; hind trochanter + femur 180–210 μm long, hind tibia + tarsus 175–220 μm long; ratio of lengths of hind tibia + tarsus to hind trochanter + femur 0.96–1.05; translucent pores present on hind coxae and tibiae. Inner edges of ostioles well-sclerotized. Circulus small and quadrate, width 40–75 μm. Cisanal setae shorter than anal lobe setae. Anal lobe cerarii each situated on a small moderately sclerotized area.

Venter. Multilocular disc pores confined to median areas of abdomen, present around vulva and in single rows across posterior edges of median areas of abdominal segments V VI. Trilocular pores moderately numerous and evenly distributed. Oral collar tubular ducts of 2 sizes, both confined to abdomen, smaller ducts present in single rows across median areas of abdominal segments V-VII, larger ducts present in small marginal groups on segments V-VII. Simple pores about twice the size of the trilocular pores, heavily sclerotized, and scattered over entire venter. Setae on median areas moderately long and fine, but those on margins short, moderately fine, and with distinctly knobbed tips.

Dorsum. Multilocular disc pores and tubular ducts absent. Trilocular pores numerous and evenly distributed. Simple pores of 2 forms; pores slightly larger than the trilocular pores, and only lightly sclerotized, scattered sparsely over entire dorsum; heavily sclerotized pores, noticeably larger than the trilocular pores, present in small groups on midline of posterior abdominal segments. Setae moderately short and stout, and with distinctly knobbed tips. Longest seta of abdominal segments VI or VII 15–30 μm long.

MATERIAL EXAMINED

Holotype ♀, **Liberia** (intercepted at New York): on wild orchids, 10.x.1957 (*C. E. Andrews, J. Hidalgo*) (USNM).

Paratypes. 4 ♀, same data as holotype (BMNH, USNM).

DISTRIBUTION. Afrotropical Region: Liberia (intercepted in the U.S.A.).

HOSTPLANT. Orchidaceae.

REMARKS. *P. orchidi* resembles the Oriental species *P. dendrobii* and *P. philippinensis*, which also occur on orchids, in having few multilocular disc pores and tubular ducts, and in having dorsal setae which are distinctly knobbed. It may be distinguished from both of these species by the presence of translucent pores on the hind tibiae and by the large, heavily sclerotized simple pores on the venter. *P. orchidi* is also similar to two orchid-infesting Afrotropical species with knobbed dorsal setae, *P. hospitus* and *P. hosyni*, both of which lack marginal tubular ducts.

Planococcus philippinensis Ezzat & McConnell

(Fig. 31)

Planococcus philippinensis Ezzat & McConnell, 1956: 95. Holotype ♀, PHILIPPINES (intercepted in Hawaii): on orchids (USNM) [not examined].

ADULT FEMALE. Mounted specimens broadly oval to rotund, length 1.4–2.3 mm, width 1.0–1.9 mm. Margin of body with a complete series of 18 pairs of cerarii, each with 2 stout conical setae. Legs stout; hind trochanter + femur about 240 μm long, hind tibia + tarsus about 220 μm long, ratio of lengths of hind tibia + tarsus to hind trochanter + femur about 0.92; translucent pores apparent on hind coxae only. Inner edges of ostioles apparently not sclerotized. Circulus absent. Cisanal setae longer that anal ring setae. Anal lobes apparently not sclerotized.

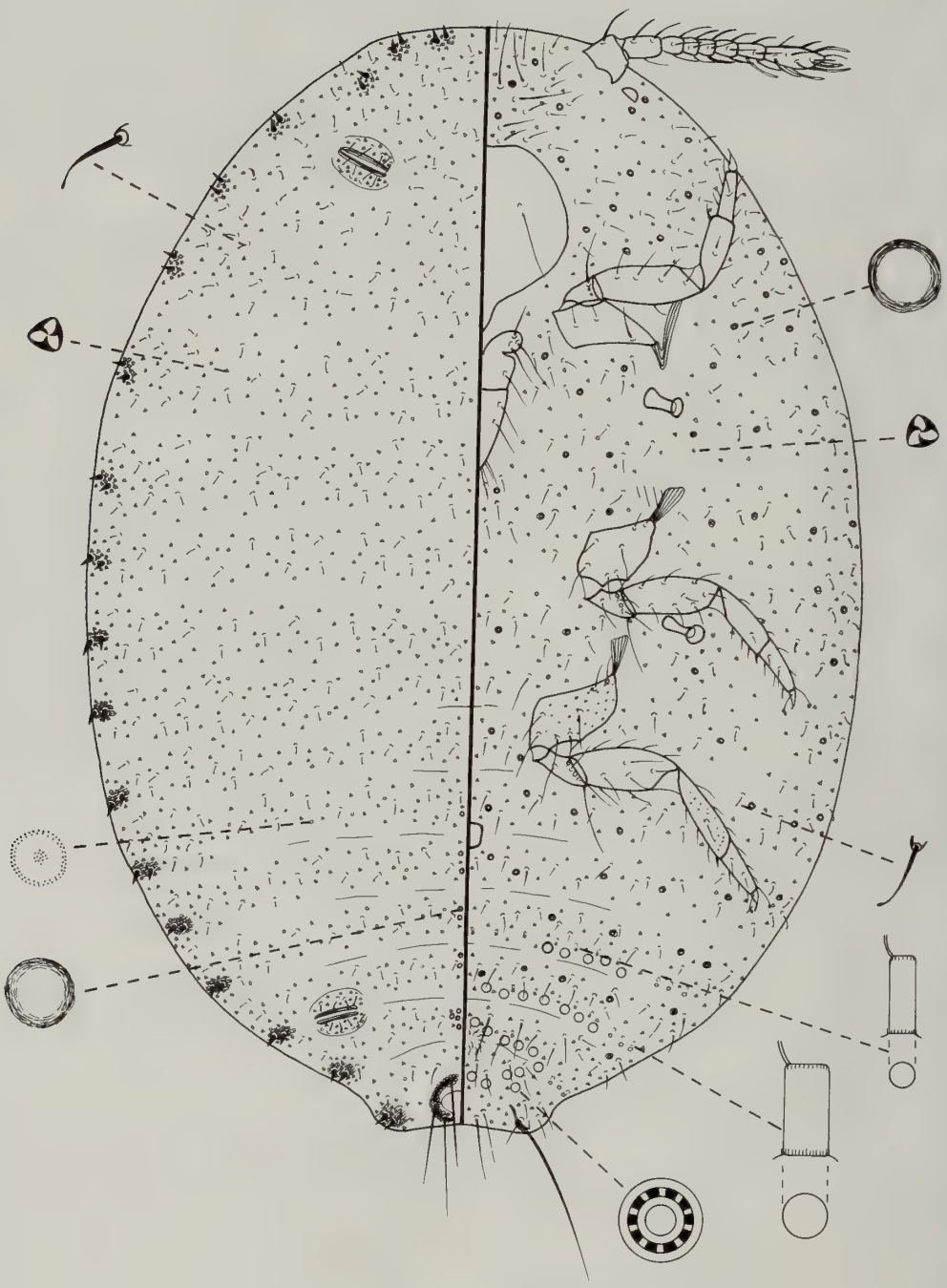

Fig. 30 *Planococcus orchidi* sp. n.

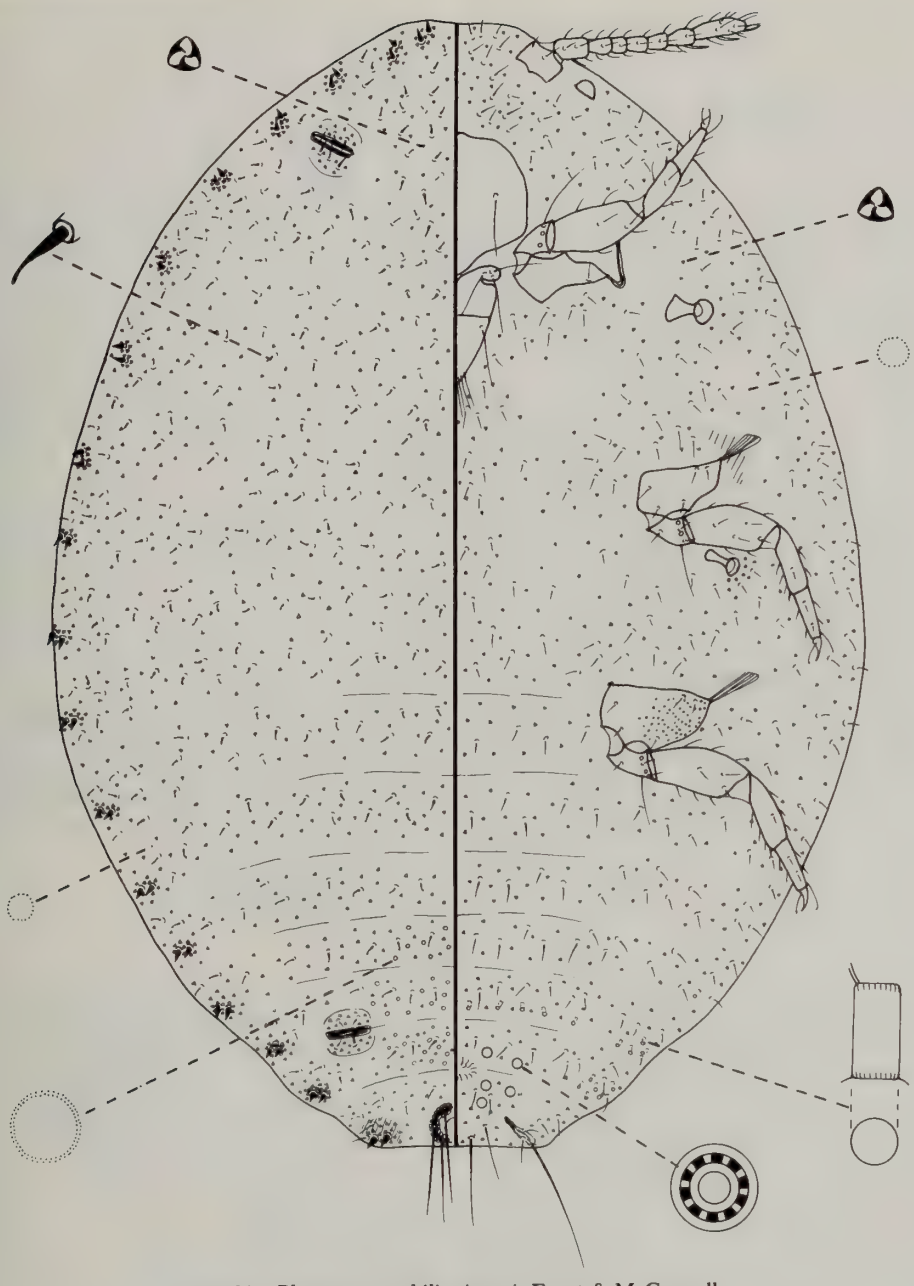

Fig. 31 *Planococcus philippinensis* Ezzat & McConnell.

Venter. Multilocular disc pores sparse and confined to median areas of abdomen, a few pores present around vulva and on posterior edges of median areas of abdominal segments V or VI. Trilocular pores moderately numerous and evenly distributed. Oral collar tubular ducts of 1 size only, confined to abdomen, present in rows across median areas of abdominal segments VI or VII, in marginal groups on segments VI or VII, and a few pores sometimes on margins of segment V. Simple pores about a third of the size of the trilocular pores, sparsely but evenly distributed.

Dorsum. Multilocular disc pores and tubular ducts absent. Trilocular pores as for venter. Simple pores, slightly smaller than the trilocular pores, sparsely scattered over most of dorsum, but those on median areas of abdominal segments numerous and noticeably larger than the trilocular

pores. Setae short and stout, slightly curved and with distinctly knobbed tips.

MATERIAL EXAMINED
1 paratype ♀, **Philippines** (intercepted at Honolulu): on *Vanda sanderiana*, 4.vi.1948 (*H. Making*) (USNM).

DISTRIBUTION. Austro-oriental Region: Philippines (intercepted in the U.S.A.).

HOSTPLANTS. Orchidaceae: *Vanda sanderiana*. Also recorded from *Cymbidium finlaysonianum*, *Vanda merrillii* and *Vandopsis lissochiloides* (all Orchidaceae) (Ezzat & McConnell, 1956).

REMARKS. This species is very similar to *P. dendrobii*, also from the Oriental Region, in having reduced numbers of tubular ducts and multilocular disc pores, translucent pores absent from the hind tibiae and dorsal setae which are short, stout and knobbed. *P. dendrobii*, however, has a circulus, and the simple pores on the dorsum of abdominal segments VI or VII are smaller than the trilocular pores. Together, these two species are probably the sister-group of two African species which also occur on orchids, *P. hosyni* and *P. orchidi*. These latter species also have knobbed dorsal setae (although indistinct in *P. hosyni*), but are distinguishable from the Oriental species by having translucent pores on the hind tibiae.

ECONOMIC STATUS. This species is a potential pest of orchids.

Planococcus principe sp. n.

(Fig. 32)

ADULT FEMALE. Mounted specimens broadly oval to rotund, length 1.6–2.8 mm, width 1.2–2.1 mm. Margin of body with complete series of 18 pairs of cerarii, each cerarii with 2 (3 or 4 in preocular cerarii) conical setae. Legs stout; hind trochanter + femur 275–295 μm long, hind tibia + tarsus 240–270 μm long, ratio of lengths of hind tibia + tarsus to hind trochanter + femur 0.84–0.92; translucent pores present on hind coxae and tibiae. Inner edges of ostioles moderately well sclerotized. Circulus quadrate, width 125–180 μm. Cisanal setae about the same length as the anal ring setae. Anal lobe area moderately well sclerotized.

Venter. Multilocular disc pores present around vulva, in rows across posterior edges of abdominal segments IV-VII and forming marginal groups on segments V or VI; a few pores sometimes present on the head. Trilocular pores numerous and evenly distributed. Oral collar tubular ducts very small, in rows across median areas of abdominal segments V-VII and in marginal groups on head, prothorax and abdominal segments V-VII; a single larger duct sometimes present on margin of segment V. Simple pores about three quarters of the size of the multilocular disc pores, scattered over venter.

Dorsum. Multilocular disc pores and tubular ducts absent. Trilocular pores as for venter. Simple pores of various sizes, larger pores about the same size as those on the venter, forming a group on the midline of each thoracic segment and scattered over submarginal areas of head and thorax, slightly smaller pores scattered over median areas of anterior abdominal segments. Setae moderately long and stout, those on the thorax sometimes distinctly knobbed, length of longest seta on abdominal segments VI or VII 30–40 μm.

MATERIAL EXAMINED
Holotype ♀, **Principe:** on cocoa, 1956 (*F. J. Simmonds*) (BMNH).
Paratypes. 7 ♀, same data as holotype (BMNH).

DISTRIBUTION. Afrotropical Region: Principe.

HOSTPLANT. Sterculiaceae: *Theobroma cacao*.

REMARKS. The only other known species of *Planococcus* which has simple pores of almost the same size as the multilocular disc pores is *P. hospitus*. The presence of marginal multilocular disc pores in *P. principe* distinguishes the 2 species.

Planococcus psidii sp. n.

(Fig. 33)

ADULT FEMALE. Mounted specimens oval, length 1.4–2.7 mm, width 0.7–1.8 mm. Margin of body with complete series of 18 pairs of ceraii, each cerarius with 2 slender conical setae. Legs elongate; hind trochanter + femur 245–285 μm, hind tibia + tarsus 255–325 μm, ratio of lengths of hind tibia + tarsus to hind trochanter + femur 1.04–1.18; large transparent pores very conspicuous on hind coxae and tibiae. Inner edges of ostioles wll sclerotized. Circulus quadrate, width 105–145 μm. Cisanal setae shorter than anal lobe setae.

Venter. Multilocular disc pores present around vulva, in rows across posterior edges of median areas of abdominal segments III-VII and across anterior edges of segments V-VII, occurring in marginal groups on segments IV-VIII, a few pores also present on median areas of the thorax. Trilocular pores sparsely but evenly distributed. Oral collar tubular ducts of 2 sizes; smaller ducts present in rows across median areas of posterior abdominal segments; larger ducts present in rows across anterior abdominal segments, scattered

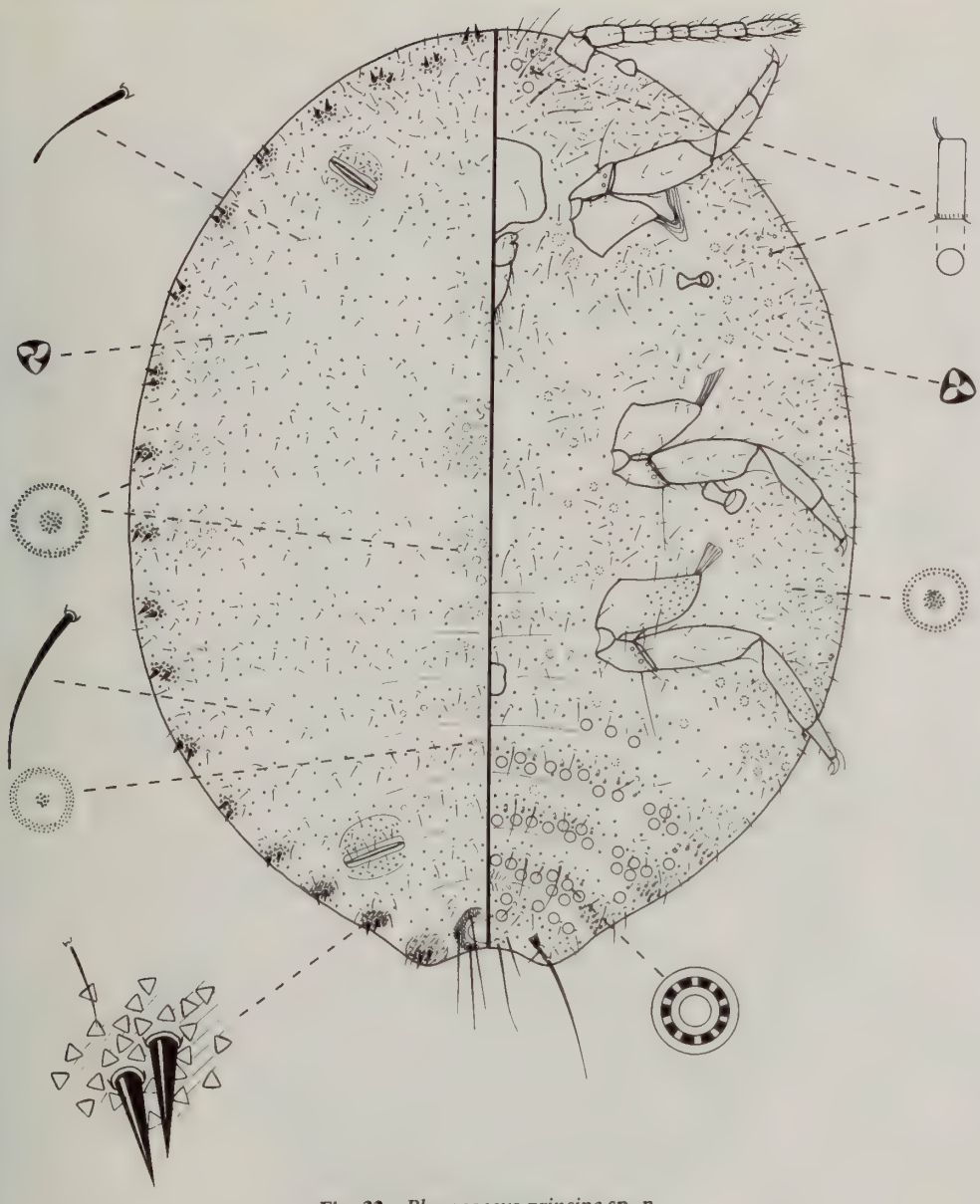

Fig. 32 *Planococcus principe* sp. n.

over median areas of thorax, occurring singly on margins of head and thoracic segments and present in marginal groups on abdomen. Simple pores about the same size as the trilocular pores, sparsely scattered over entire venter.

Dorsum. Multilocular disc pores and tubular ducts absent. Trilocular pores sparse and some appear to be associated with the bases of the larger setae. Simple pores of 2 sizes, smaller pores minute and sparsely scattered over entire dorsum, larger pores about the same size as those on the venter and forming a small group on the midline of each thoracic and anterior abdominal segment. Setae short and stout, blunt-ended or slightly knobbed, length of longest seta on abdominal segments VI or VII 15–22 μm.

MATERIAL EXAMINED

Holotype ♀, **West Malaysia:** Flemming Est., on *Psidium guajava*, 21.i.1988 (*K. C. Khoo*) (BMNH).

Paratypes. 11 ♀, same data as holotype (BMNH).

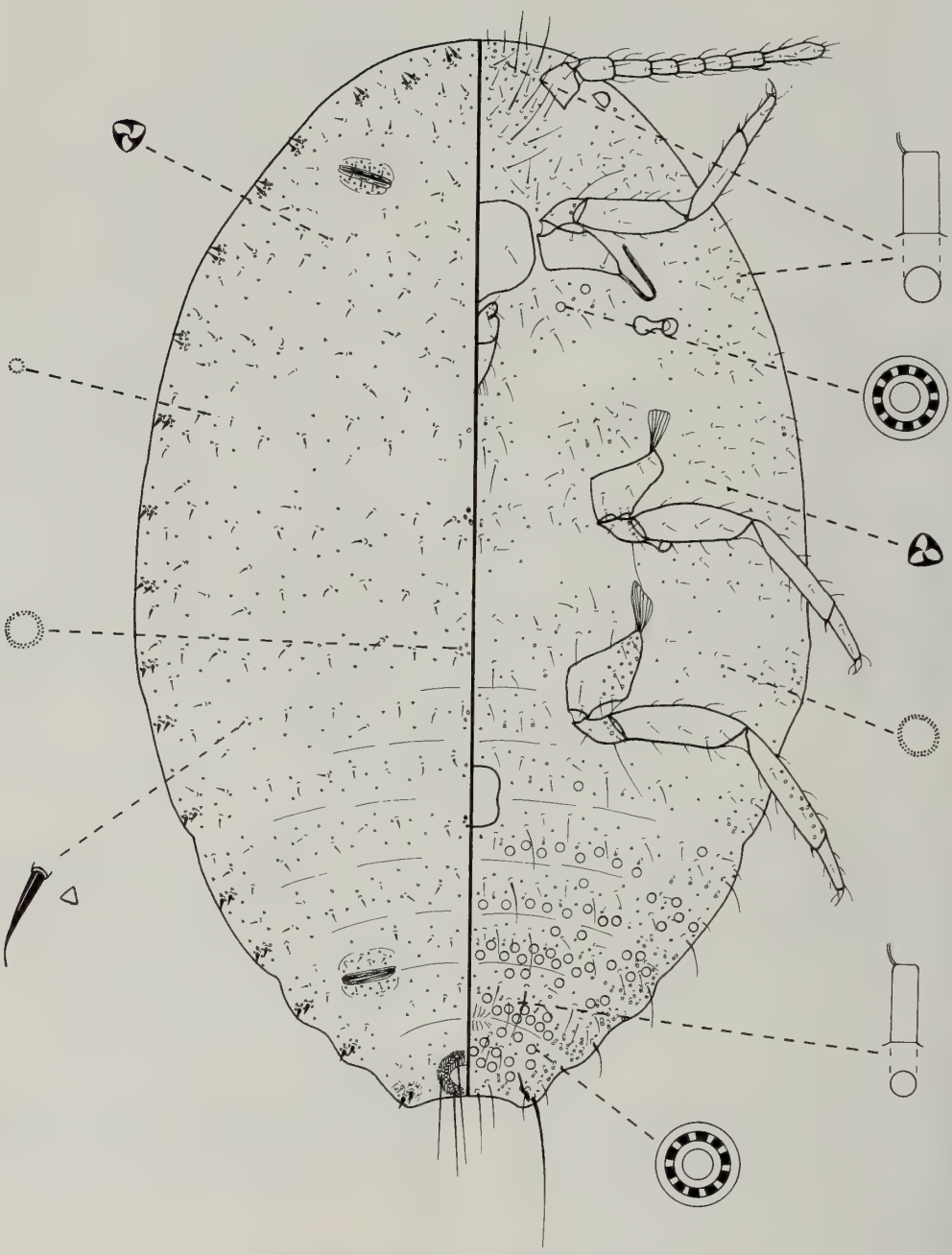

Fig. 33 *Planococcus psidii* sp. n.

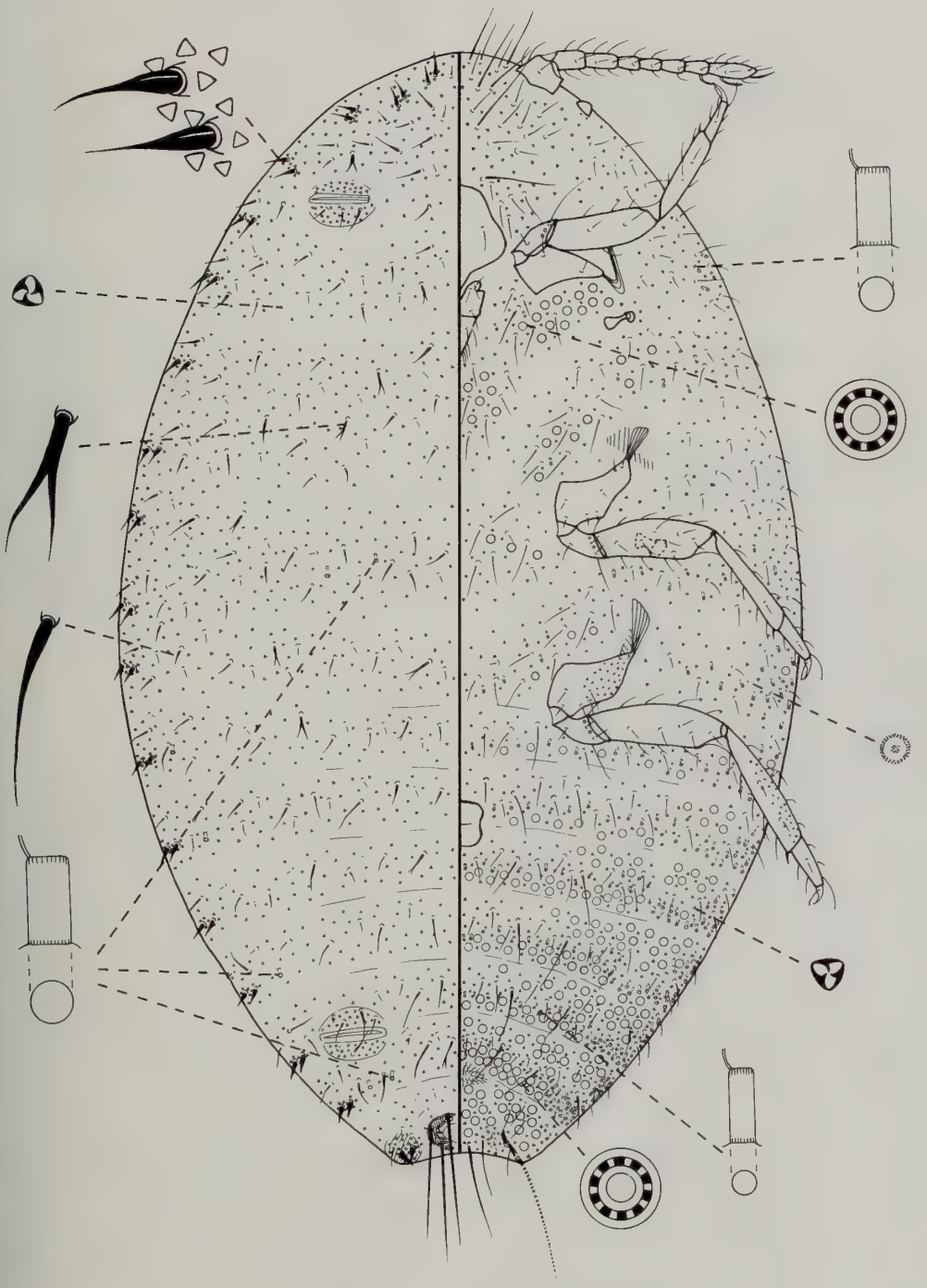

Fig. 34 *Planococcus subterraneus* De Lotto.

DISTRIBUTION. Austro-oriental Region: West Malaysia.

HOST. Myrtaceae: *Psidium guajava*.

REMARKS. *P. psidii* is superficially similar to *P. minor* in its distribution of multilocular disc pores and oral collar tubular ducts. However, the short blunt-ended dorsal setae and the large translucent pores on the hind legs distinguish *P. psidii*. This species may actually be more closely related to the *dorsospinosus*-group, as the trilocular pores are somewhat associated with some of the larger dorsal setae.

Planococcus subterraneus De Lotto

(Fig. 34)

Planococcus subterraneus De Lotto, 1964: 377. Holotype ♀, SOUTH AFRICA: Pretoria, on roots of *Ficus* sp. (BMNH) [examined].

ADULT FEMALE. Mounted specimen elongate-oval, length 2.3 mm, width 1.4 mm. Margin of body with complete series of 18 pairs of cerarii, each cerarius with 2 slender conical setae. Legs elongate; hind trochanter + femur 375 μm long, hind tibia + tarsus 405 μm long, ratio of lengths of hind tibia + tarsus to hind trochanter + femur 1.08; translucent pores present on hind coxae and tibiae. Inner edges of ostioles lightly sclerotized. Circulus quadrate, width 170 μm. Cisanal setae shorter than anal ring setae. Anal lobe cerarii each situated on a small, moderately sclerotized area.

Venter. Multilocular disc pores numerous around vulva, present in rows across posterior edges of median areas of all abdominal segments and across anterior edge of segments IV-VII, present in marginal groups on abdominal segments II-VIII, and numerous over median area of thorax. Trilocular pores moderately numerous and evenly distributed. Oral collar tubular ducts of 2 sizes; smaller ducts present sparsely in rows across median areas of all abdominal segments; slightly larger ducts sparsely scattered over median areas of head and thorax, in marginal groups on all abdominal segments, and a few ducts present on margins adjacent to front coxae. Simple pores about half the size of the trilocular pores, sparsely but evenly distributed.

Dorsum. Multilocular disc pores absent. Tubular ducts, larger than the larger ducts on the venter and without noticeable rims, present singly adjacent to some abdominal cerarii (except for one side of the preanal segment on which 2 ducts are present), and a few ducts scattered over median areas of the thorax. Trilocular pores as for venter. Simple pores not apparent. Setae long, stout and flagellate, some strongly bifurcate, longest seta on abdominal segments VI or VII about 75 μm long.

MATERIAL EXAMINED

Known from holotype ♀ only, **South Africa:** Pretoria, on roots of *Ficus* sp., 15.viii.1958 (*H. K. Munro*) (BMNH).

DISTRIBUTION. Afrotropical Region: South Africa.

HOSTPLANT. Moraceae: *Ficus* sp.

REMARKS. *P. subterraneus* is very similar to *P. flagellatus* in its distribution of multilocular disc pores and possession of long, fleshy dorsal setae. It differs primarily by having many bifurcate dorsal setae and by lacking tubular ducts on the head. As *P. subterraneus* is known from a single specimen, and *P. flagellatus* from only a few specimens which vary greatly, it is possible that further collecting may show these two species to be the same.

Both *P. subterraneus* and *P. flagellatus* belong to the *citri*-group by virtue of their arrangement of multilocular disc pores and tubular ducts. Their distinctive characteristic is the very long, fleshy and sometimes bifurcate, dorsal setae.

Planococcus sulawesi sp. n.

(Fig. 35)

ADULT FEMALE. Mounted specimens oval, length 1.6–1.7 mm, width 0.8–0.9 mm. Margin of body with a complete series of 18 pairs of cerarii, each cerarius with 2 stout conical setae. Legs elongate; hind trochanter + femur 285–305 μm long, hind tibia + tarsus 305–325 μm long, ratio of hind tibia + tarsus to hind trochanter + femur 1.06–1.07; translucent pores present on hind coxae and tibiae. Inner edges of ostioles lightly sclerotized. Circulus quadrate and of moderate size, width about 135 μm. Cisanal setae shorter than anal ring setae. Anal lobe cerarii each situated on a small sclerotized area.

Venter. Multilocular disc pores confined to median areas of body, present around vulva and in rows across posterior edges of abdominal segments III-VII and across anterior edges of segments VI or VII; a few pores scattered over thorax. Trilocular pores moderately numerous and evenly distributed. Oral collar tubular ducts of 2 sizes; smaller ducts present in rows across median areas of abdominal segments IV-VII; larger ducts present in rows across median areas of segments II-VII, in marginal groups on all thoracic and abdominal segments, and scattered over

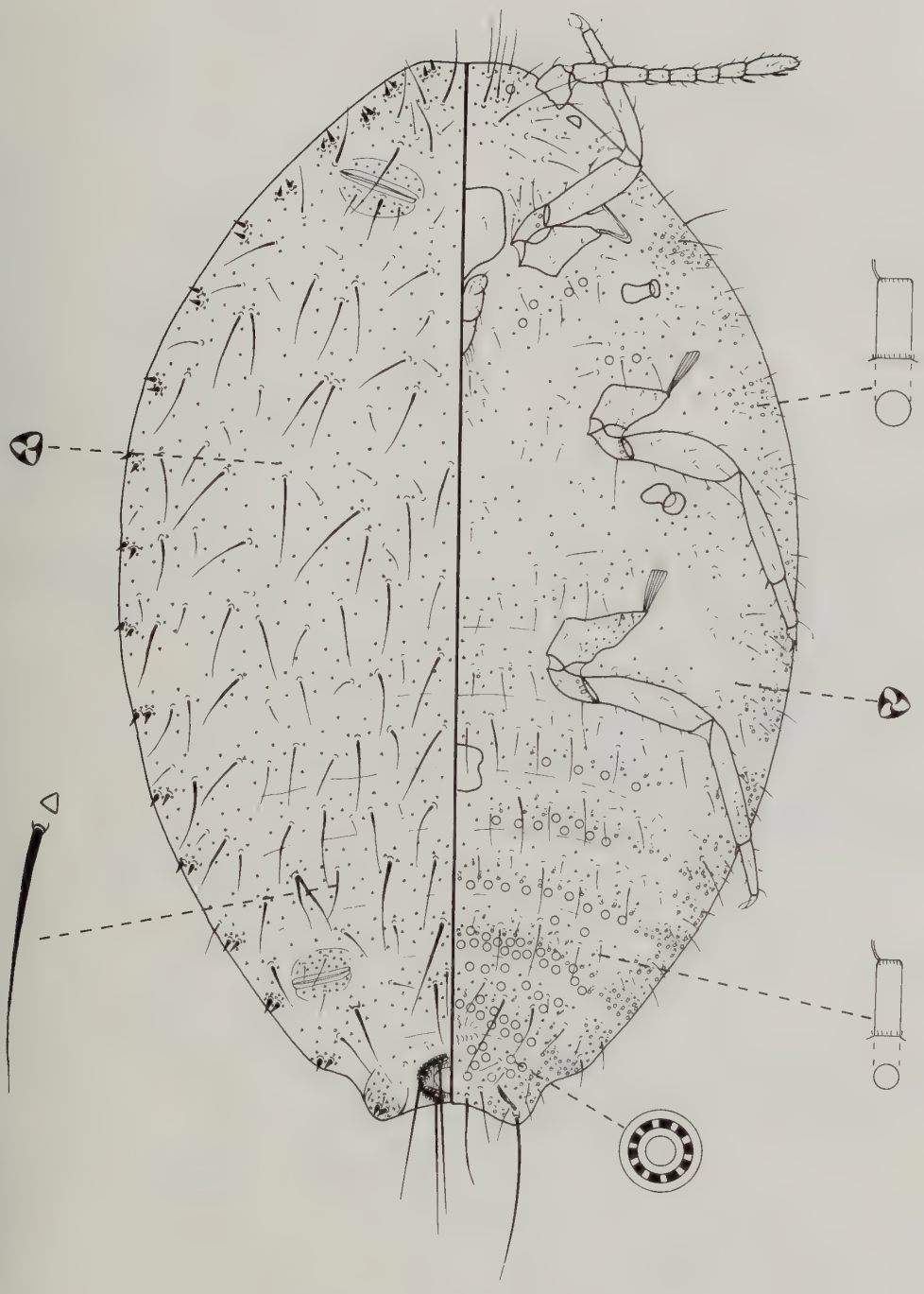

Fig. 35 *Planococcus sulawesi* sp. n.

median areas of thorax. Simple pores not apparent in the specimens examined.

Dorsum. Multilocular disc pores and tubular ducts absent. Trilocular pores moderately numerous and slightly aggregated around the bases of the larger setae. Simple pores not apparent in the specimens examined. Setae stout and very long, occasionally bifurcate, length of longest seta on abdominal segment VI or VII about 100 μm.

MATERIAL EXAMINED

Holotype ♀, **Indonesia:** Sulawesi Utara, Dumoga-Bone National Park, Gunung Mogogonipa, on Urticaceae, 6.iv.1985 (*J. H. Martin*) (BMNH).

Paratype. 1 ♀, same data as holotype (BMNH).

DISTRIBUTION. Austro-oriental Region: Indonesia.

HOSTPLANT. Urticaceae.

REMARKS. *P. sulawesi* is a member of the *dorsospinosus*-group by virtue of its arrangement of multilocular disc pores and tubular ducts, and by having trilocular pores associated with the bases of the larger dorsal setae. It is readily distinguished from the other members of this group by its very long dorsal setae. *P. sulawesi* superficially resembles *P. flagellatus*, *P. subterraneus* and *P. lilacinus* in the length of its dorsal setae, but can be distinguished from the former two species, both Afrotropical, by lacking marginal multilocular disc pores, from *P. lilacinus* by having multilocular disc pores present on the thorax and by having elongate legs, and from all three by having trilocular pores associated with the bases of the dorsal setae.

Planococcus taigae Danzig

(Fig. 36)

[*Planococcus vovae* (Nasonov) Danzig, 1980: 168, in part, illustration. Misidentification.]

Planococcus taigae Danzig, 1986: 19. Holotype ♀, U.S.S.R: Southern Sakhalin, on *Juniperus sibirica* (ZIL) [not examined].

ADULT FEMALE. Mounted specimens oval, length 1.4–2.3 mm, width 1.0–1.7 mm. Margin of body with a complete series of 18 pairs of cerarii, each with 2 slender, conical setae, noticeably more slender and flagellate towards the anterior end of the body. Legs elongate; hind trochanter + femur 210–295 μm long, hind tibia + tarsus 220–315 μm long, ratio of lengths of hind tibia + tarsus to hind trochanter + femur 1.05–1.06; translucent pores present on hind coxae and 2–4 pores just visible on each hind tibia. Ostioles very weakly defined. Circulus not apparent in specimens examined, but indicated in illustration by Danzig (1980). Cisanal setae shorter than anal lobe setae. Anal lobe cerarii each situated on a small, lightly sclerotized area.

Venter. Multilocular disc pores confined to median areas only, situated around vulva, in rows across posterior edges of abdominal segments IV-VII, and a few pores present on anterior edges of segments V-VII. Trilocular pores moderately numerous and evenly distributed. Oral collar tubular ducts of 2 sizes, smaller ducts present sparsely in rows across median areas of abdominal segments V-VII, larger ducts present in rows across median areas of segments II-VII and numerous around margin of entire venter. Simple pores minute, sparsely but evenly distributed.

Dorsum. Multilocular disc pores absent. Trilocular pores and simple pores as for venter. Tubular ducts, variable in size but larger than those on the venter and without apparent rims, numerous over entire dorsum, occurring in rows of up to 24 ducts across abdominal segments. Setae short and stout, longest setae on abdominal segments VI or VII about 13 μm long.

MATERIAL EXAMINED

2 paratype ♀, **U.S.S.R:** Primorye Region, Sudzukhinskiy Nature Reserve, on *Juniperus rigida*, 15.vii.1969 (*E. Danzig*); 1 paratype ♀, Southern Sakhalin, Staroduskoye, 4.vii.1968 (*S. Barfeneva*) (all BMNH).

DISTRIBUTION. Palaearctic Region: U.S.S.R., from Karelia to Kuril Islands (Danzig, 1980).

HOSTPLANTS. Cupressaceae: *Juniperus communis, J. rigida, J. siberica* (Danzig, 1986).

REMARKS. The above description was based on only three specimens, so the ranges of characters given may be less than actually occurs throughout the species.

P. taigae is very similar to *P. vovae* which also occurs only on Cupressaceae, and replaces the latter species in the eastern Palaearctic Region. *P. taigae* can be distinguished from *P. vovae* by its greater numbers of dorsal tubular ducts (total of more than 200), presence of ventral tubular ducts on the head, and indistinct ostioles. *P. vovae* has variable numbers of dorsal tubular ducts, but never more than a total of 110, lacks ventral tubular ducts on the head and has well-defined ostioles. Both of these species are similar to *Crisicoccus matesovae* (Fig. 37), also occurring on

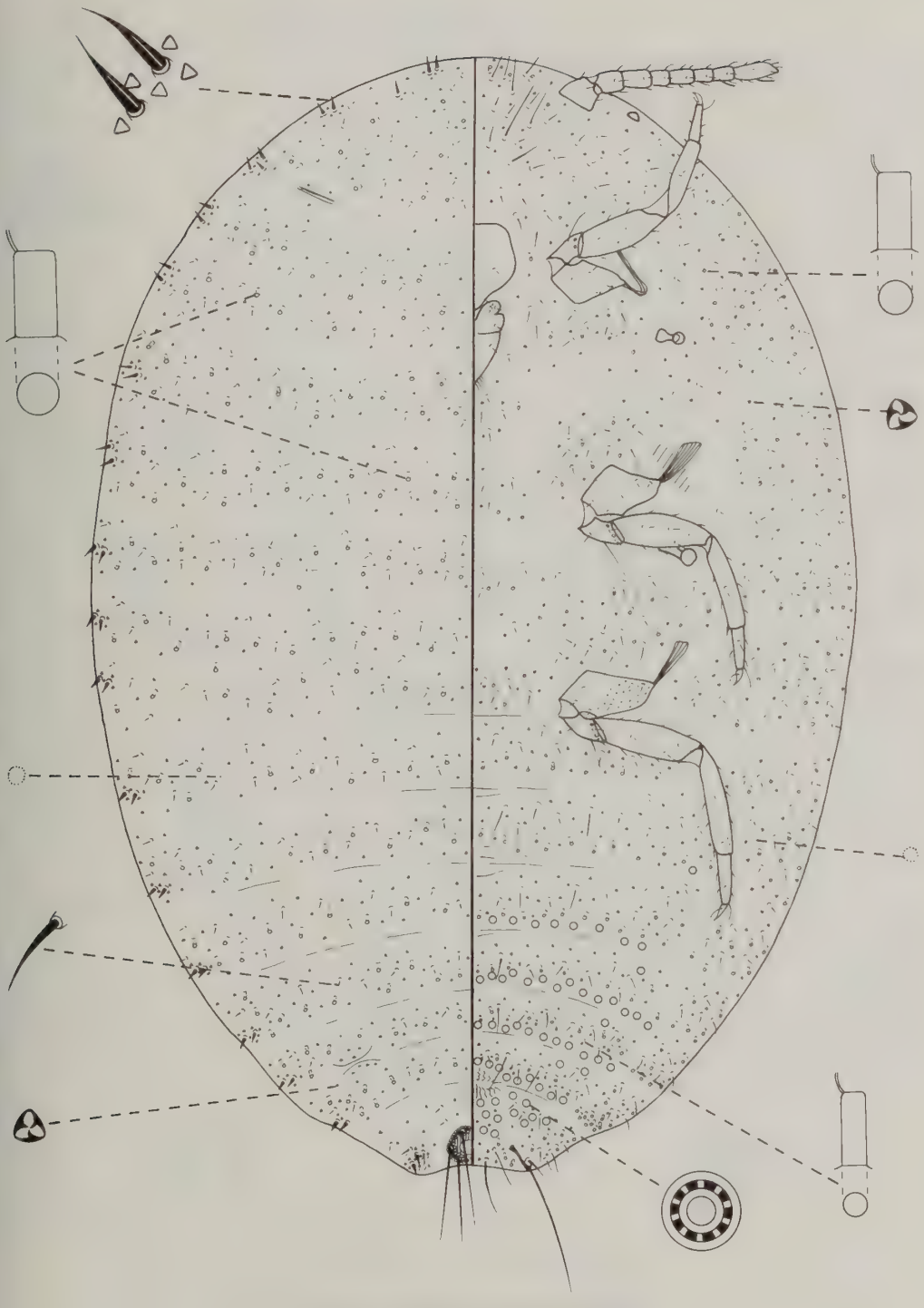

Fig. 36 *Planococcus taigae* Danzig.

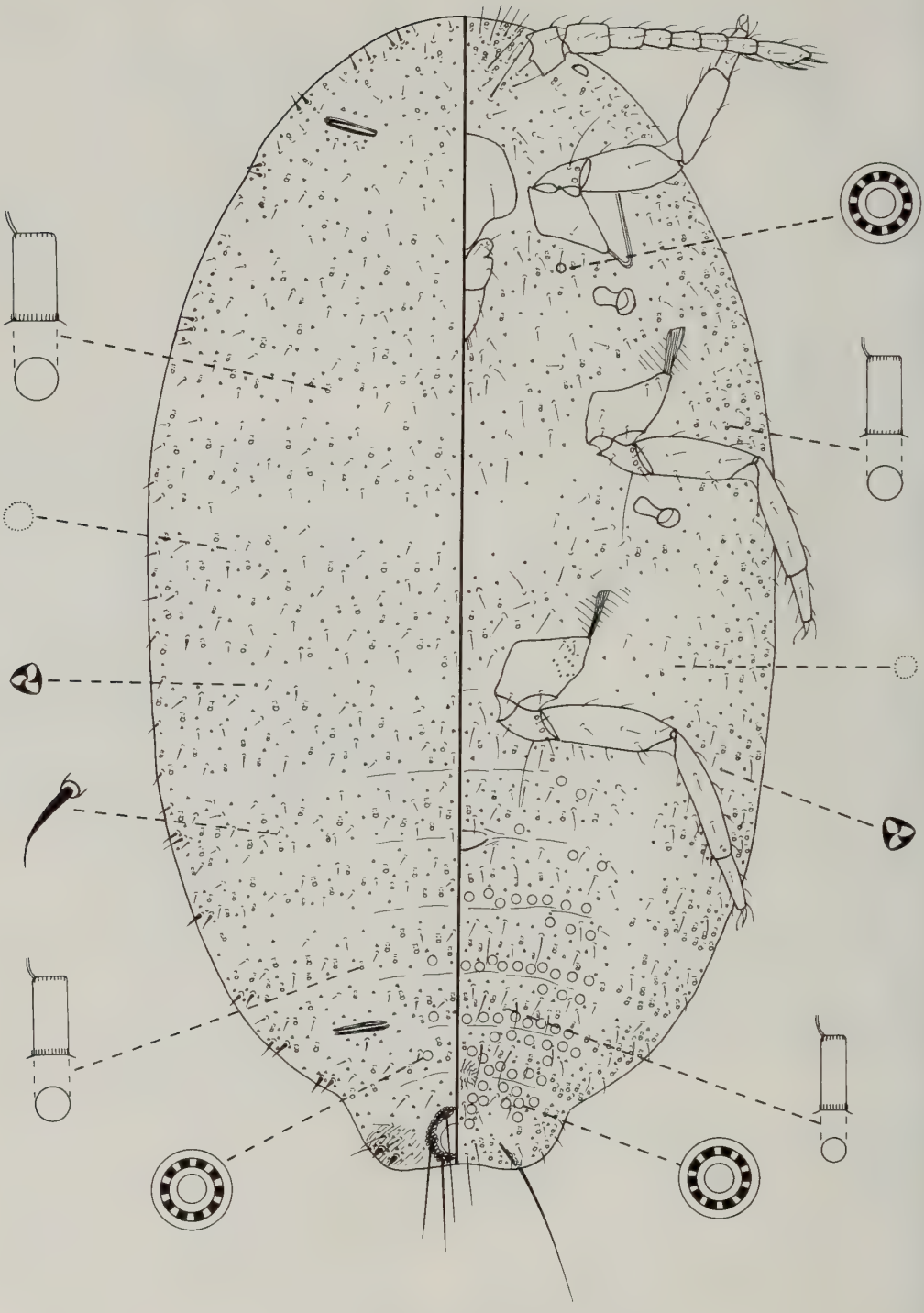

Fig. 37 *Crisicoccus matesovae* (Danzig).

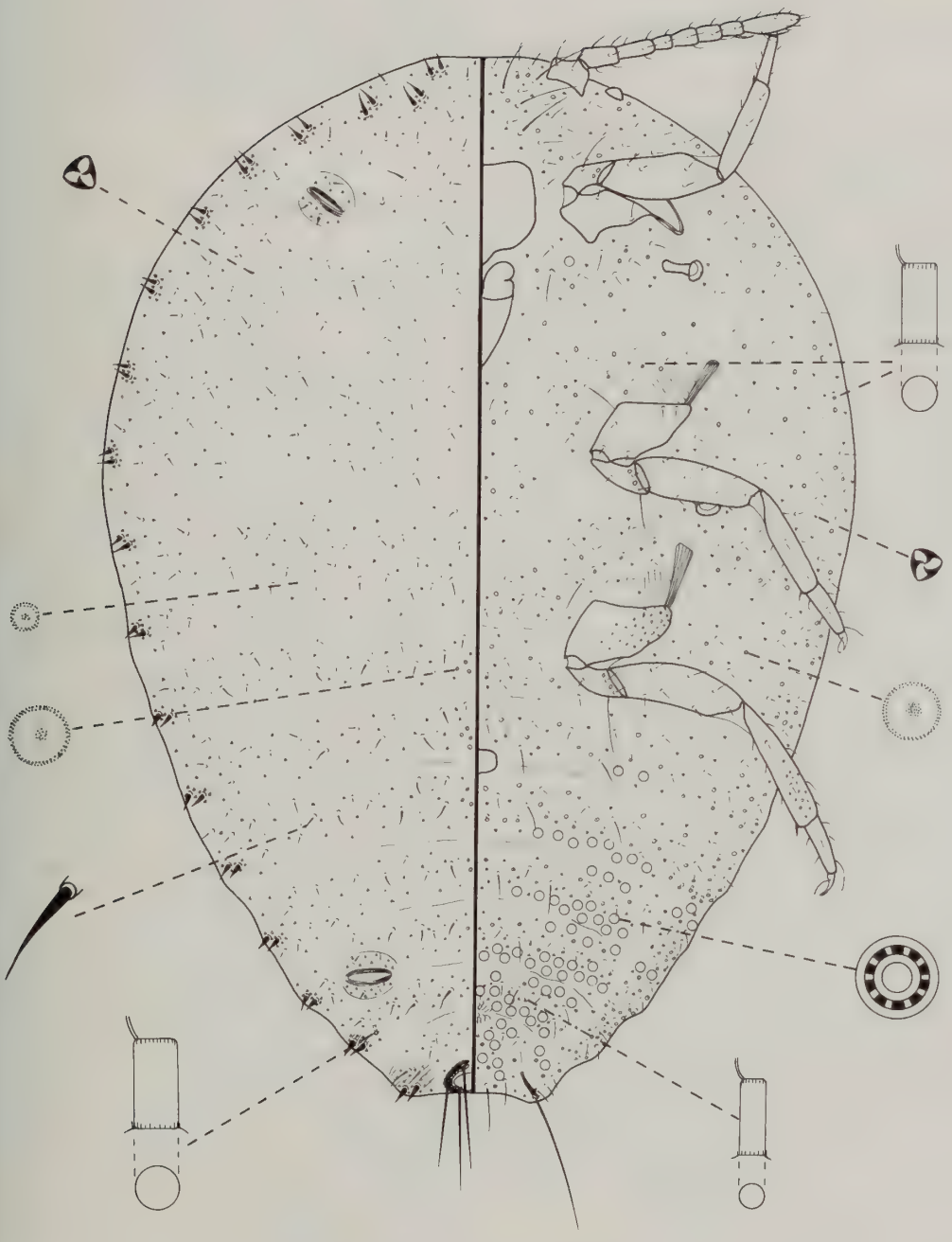

Fig. 38 *Planococcus tanzaniensis* sp. n.

Cupressaceae in the U.S.S.R., but this species has dorsal multilocular disc pores and fewer than 18 pairs of cerarii.

Planococcus tanzaniensis sp. n.

(Fig. 38)

ADULT FEMALE. Mounted specimens broadly oval to rotund, length 1.5–2.5 mm, width 1.1–2.0 mm. Margin of body with a complete series of 18 pairs of cerarii, each cerarius with 2 moderately stout conical setae. Legs elongate; hind femur + trochanter 250–305 μm long, hind tibia + tarsus 295–345 μm long, ratio of lengths of hind tibia + tarsus to hind trochanter + femur 1.09–1.18; translucent pores present on hind coxae and tibiae. Inner edges of lips of ostioles moderately sclerotized. Circulus quadrate, width 95–125 μm. Cisanal setae shorter than anal ring setae. Anal lobe cerarii each situated on a small, moderately sclerotized area.

Venter. Multilocular disc pores present around vulva, in rows across posterior edges of median areas of abdominal segments IV-VII and across anterior edges of segments V-VII, and present in small numbers on margins of segments V-VII. Trilocular pores moderately numerous and evenly distributed. Oral collar tubular ducts of 2 sizes; smaller ducts present in rows across median areas of abdominal segments; larger ducts scattered over median areas of thorax, present in small numbers on margins of head and thoracic segments, and in small groups on margins of all abdominal segments except segment IX and sometimes VIII. Simple pores about the same size as the trilocular pores, moderately numerous and scattered over entire venter.

Dorsum. Multilocular disc pores absent. Trilocular pores as for venter. Tubular ducts, larger than the larger size on the venter and without apparent rims, sometimes present singly adjacent to posterior cerarii. Simple pores of 2 sizes, larger simple pores slightly larger than the trilocular pores, present in small median groups on anterior abdominal segments, smaller pores, about half the size of the trilocular pores, scattered over entire dorsum. Setae flagellate, long and stout, longest seta on abdominal segments VI or VII about 30 μm long.

MATERIAL EXAMINED

Holotype ♀, **Tanzania:** Selem, on *Hevea braziliensis*, 8.i.1987 (*S. Oswald*) (BMNH).

Paratypes. 13 ♀, same data as holotype (BMNH).

DISTRIBUTION. Afrotropical Region: Tanzania.

HOSTPLANT. Euphorbiaceae: *Hevea braziliensis*.

REMARKS. *P. tanzaniensis* is most similar to *P. aemulor* and *P. nigritulus* in its body shape, distribution of multilocular disc pores, large ventral simple pores, long stout dorsal setae and absence of tubular ducts from abdominal segment IX. It can be distinguished from both species by its possession of tubular ducts on the median areas of the thorax.

Planococcus vovae Nasonov

(Fig. 39)

Pseudococcus (Dactylopius) vovae Nasonov, 1908: 484. Lectotype ♀, U.S.S.R.: on *Juniperus communis* (ZIL) designated by Danzig (1980) [examined].

Pseudococcus inamabilis Hambleton, 1935: 112. Syntype ♀, BRAZIL: on *Cupressus glauca* (IBSP, ?lost) [not examined]. [Synonymized by Cox & Ben-Dov (1986).]

Allococcus inamabilis (Hambleton) Ezzat & McConnell, 1956: 15.

Allococcus vovae (Nasonov) Zahradnik, 1959: 537.

Planococcus vovae (Nasonov) Danzig, 1980: 168; Cox & Ben-Dov, 1986: 485; Danzig, 1986: 18.

ADULT FEMALE. Mounted specimens oval, length 1.3–3.4 mm, width 0.7–2.3 mm. Margin of body with a complete series of 18 pairs of cerarii, each with 2 slender conical setae, noticeably more slender and flagellate towards the anterior end of the body. Legs elongate; hind trochanter + femur 230–355 μm long, hind tibia + tarsus 265–400 μm long, ratio of lengths of hind tibia + tarsus to hind trochanter + femur 1.09–1.17; translucent pores present on hind coxae and a few pores sometimes visible on each hind tibia. Ostioles well defined, but with lip edges weakly sclerotized. Circulus quadrate, width 75–135 μm. Cisanal setae shorter than anal lobe setae. Anal lobe cerarii each situated on a small, lightly sclerotized area.

Venter. Multilocular disc pores confined to median areas of abdomen, situated around vulva and in rows across posterior edges of abdominal segments IV-VII, and a few pores present on anterior edges of segments V-VII. Trilocular pores moderately numerous and evenly distributed. Oral collar tubular ducts of 2 sizes; smaller ducts present sparsely in rows across median areas of abdominal segments V-VII; larger ducts present in rows across median areas of segments II-VII, in marginal groups on all abdominal segments and scattered over median areas of thorax, and a few

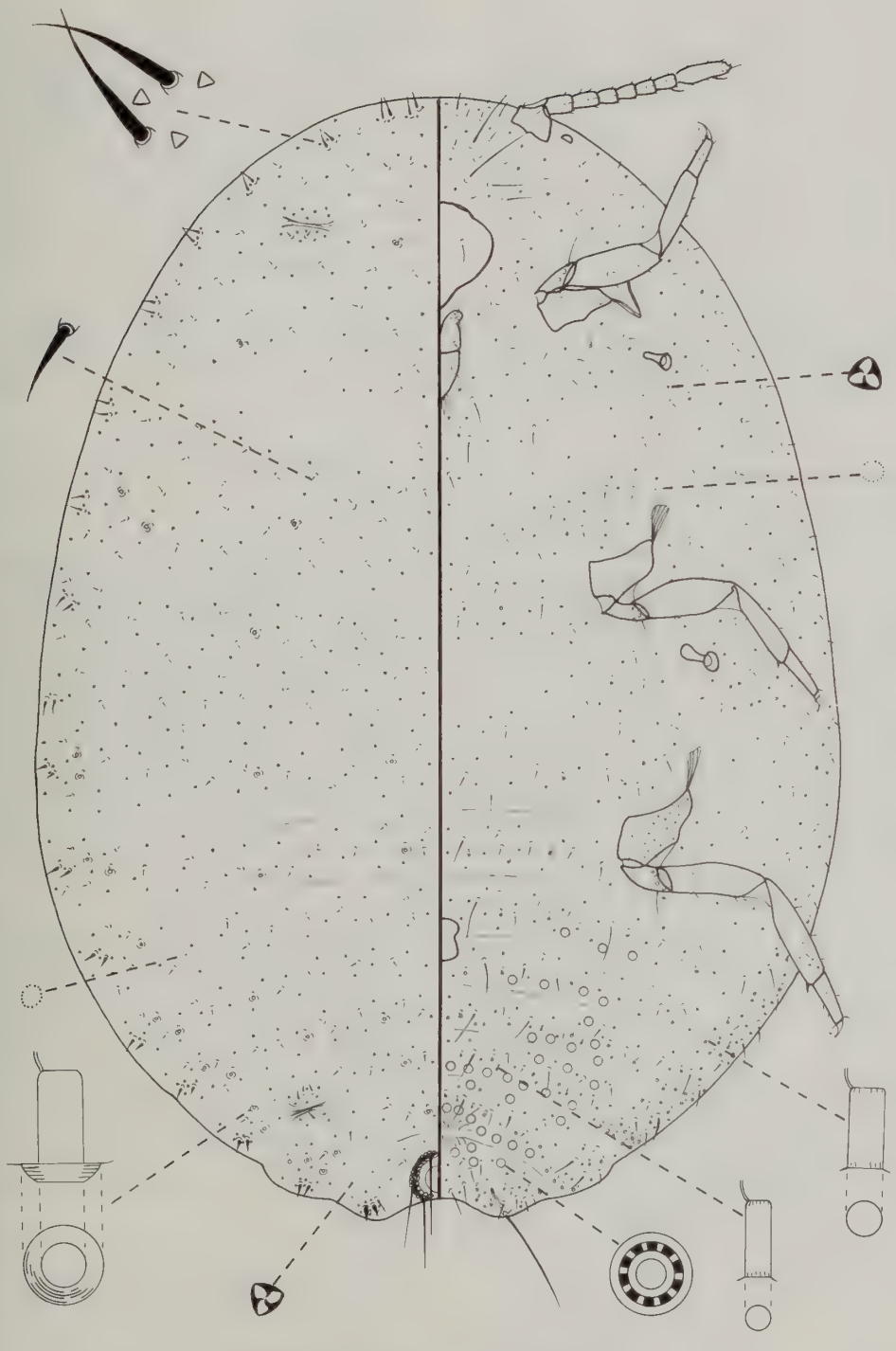

Fig. 39 *Planococcus vovae* (Nasonov).

ducts sometimes present on margins of thoracic segments. Simple pores minute, evenly but sparsely distributed.

Dorsum. Multilocular disc pores absent. Trilocular pores and simple pores as for venter. Tubular ducts, variable in size but larger than those on the venter and usually with rims, variable in number, most numerous at posterior end of body, scattered over dorsum, a total of 13–110 ducts present over entire dorsum. Setae moderately long and fine, longest seta on abdominal segments VI or VII about 20–35 μm long.

MATERIAL EXAMINED

89 ♀ (including type material listed below and original material of *Pseudococcus inamabilis*) (BMNH, MNNH, USNM, VCI, ZIL).

Pseudococcus vovae Nasonov. Lectotype ♀, **U.S.S.R.:** Varsoviensi Province, on *Juniperus communis*, 24.vii.1906 (ZIL).

DISTRIBUTION. Palaearctic Region: Cyprus, England, Germany, Greece, Hungary, Iran, Israel, Italy, Morocco, Poland, Turkey, U.S.S.R. Neotropical Region: Brazil.

HOSTPLANTS. Cupressaceae: *Cupressus glauca, C. gloveniana, C. macrocarpa, C. sempervirens, C. virginiana, Juniperus communis, Thuja occidentalis*.

REMARKS. *P. vovae* is similar to *P. taigae*, but differs in having fewer ducts on the dorsum, in lacking ventral tubular ducts on the head, in having more distinct ostioles, and by having more flagellate dorsal and cerarian setae. Both of these species occur only on Cupressaceae, as does the similar *Crisicoccus matesovae* (Fig. 37).

P. vovae has variable numbers of dorsal tubular ducts, as discussed by Cox & Ben-Dov (1986). In specimens from the Mediterranean Basin, these ducts occur in low numbers and may be confined to the posterior abdominal segments. In those from central Europe, however, these ducts are much more numerous and occur over the entire dorsum. The latter specimens resemble *P. taigae*, from the eastern Palaearctic Region, which has even more numerous dorsal ducts. Further work is needed, based on many more specimens from central Europe and the eastern Palaearctic Region, to determine whether there is a single, variable species, or a complex of species with different geographical distributions.

Ezzat & McConnell (1956) erected a new genus *Allococcus*, with *Pseudococcus inamabilis* as the type-species. *Allococcus* and *Planococcus* were distinguished by these authors by the nature of the dorsal tubular ducts, those of *Allococcus* having rims, and those of *Planococcus* not having rims. However, dorsal tubular ducts with the appearance of oral rims occur variably in some individuals of several species of *Planococcus*, including the type-species, *P. citri*. These ducts are not as large, or with such pronounced rims, as those found in other genera such as *Pseudococcus*. Following the synonymy of *Pseudococcus inamabilis* with *Pseudococcus vovae* and the placement of this species in *Planococcus*, *Allococcus* became a synonym of *Planococcus*. Most of the species contained in *Allococcus* at that time were transferred to a new genus, *Delottococcus*, by Cox & Ben-Dov (1986).

ECONOMIC STATUS. This species often reaches high numbers on *Cupressus* used as shelter trees in orchards, but is usually heavily parasitized.

Planococcus zairensis sp. n.

(Fig. 40)

ADULT FEMALE. Mounted specimens broadly oval to rotund, length 1.2–1.7 mm, width 0.7–0.9 mm. Margin of body with a complete series of 18 pairs of cerarii, each with 2, somewhat elongate, conical setae. Legs elongate; hind trochanter + femur 170–195 μm long, hind tibia + tarsus 295–220 μm long; ratio of lengths of hind tibia + tarsus to hind trochanter + femur 1.12–1.14; translucent pores present on hind coxae and tibiae. Inner edges of ostioles moderately sclerotized. Circulus small and quadrate, width 40–55 μm. Cisanal setae shorter than anal lobe setae. Anal lobe cerarii each situated on a small, moderately sclerotized area.

Venter. Multilocular disc pores sparsely present around vulva, 1–3 pores present on posterior edges of median areas of abdominal segment VI, and 1 pore sometimes present on each margin of segments VI or VII. Trilocular pores sparsely but evenly distributed. Oral collar tubular ducts of 1 size only, confined to abdomen, present in small numbers on median areas of abdominal segments V-VII and single ducts sometimes present on margins of segments VI or VII. Simple pores about half the size of the trilocular pores, scattered over entire venter.

Dorsum. Multilocular disc pores and tubular ducts absent. Trilocular pores moderately numerous and evenly distributed. Simple pores about twice the size of the trilocular pores, present in small groups on midline of head, thorax and anterior abdominal segments. Setae short and stout, longest seta of abdominal segments VI or VII 12–15 μm long.

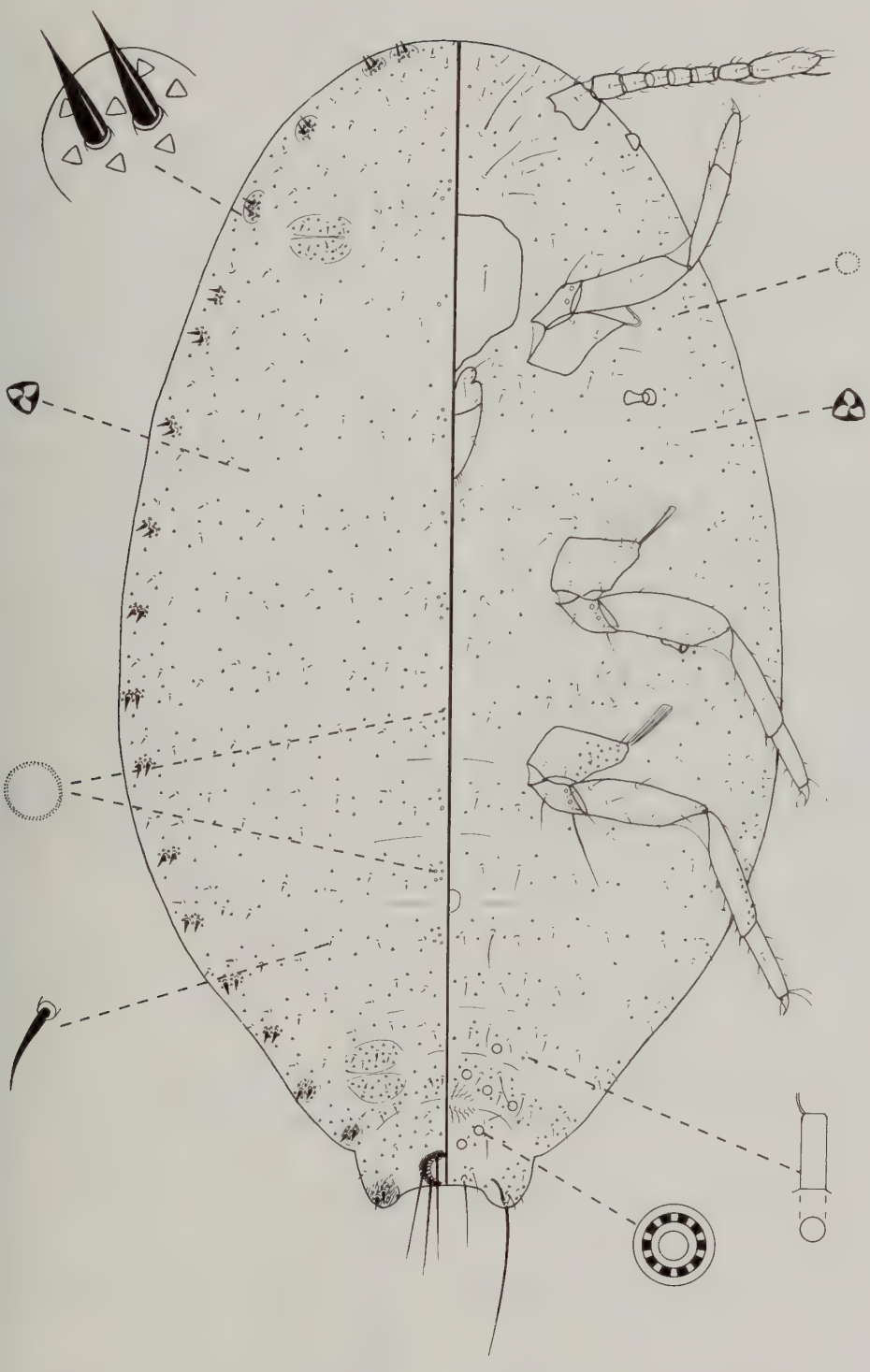

Fig. 40 *Planococcus zairensis* sp. n.

MATERIAL EXAMINED

Holotype ♀, **Zaire** (Belgian Congo): Elisabethville [Lubumbashi], 1919 (*Ringeot*) (MNHH).

Paratypes. 7 ♀ (1 on same slide as holotype), same data as holotype (BMNH, MNNH).

DISTRIBUTION. Afrotropical Region: Zaire.

HOSTPLANTS. Unknown.

REMARKS. *P. zairensis* is similar to the orchid-feeding *dendrobii*-group comprising *P. dendrobii, P. hosyni, P. orchidi* and *P. philippinensis* in its size, body shape, and distribution of multilocular disc pores and tubular ducts. It differs from these species in lacking knobbed dorsal setae. It is also similar to *P. boafoensis*, but lacks the distinctly protruding cerarii of this species.

REFERENCES

Ashmead, W. H. 1879. Injurious and beneficial insects found on the orange trees of Florida. *The Canadian Entomologist* **11:** 159–160.

Avasti, R. K. & Shafee, S. A. 1987. Indian Pseudococcidae (Homoptera : Coccoidea). *Indian Journal of Systematic Entomology* **4:** 1–54.

Betrem, J. G. 1936. De Oecologie en Epidemiologie van de Witteluizen. *Archief voor de Koffiecultuur in Nederlandsch-Indië* **10:** 85–186.

—— 1937. De Morphologie en Systematiek van Enkele van de Vooraamste Witte – Luizensoorten van Java. *Archief voor de Koffiecultuur in Nederlandsch-Indië* 11: 1–118.

Boisduval, A. M. 1867. *Essai sur l'entomologie horticole comprenant l'histoire des insectes nuisables à l'horticulture avec l'indication des moyens propres à les éloigner ou a les détruire et l'histoire des insectes et autres animaux utiles aux cultures.* 648 pp. Paris.

Borchsenius, N. S. 1949. Sucking insects Vol. 7. *Suborder mealybugs and scale insects (Coccoidea), Family mealybugs (Pseudococcidae). Fauna SSSR.* Novaya Seriya 38. 383 pp. [In Russian.]

—— 1962. Notes on the Coccoidea of China. X. Descriptions of some new species of Pseudococcidae (Homoptera, Coccoidea). Scientific results of the Chinese-Soviet expeditions of 1955–1957 to south-western China. *Entomologicheskoe Obozrenie* **41:** 583–595. [In Russian with English summary.]

Brain, C. K. 1915. The Coccidae of South Africa. -I. *Transactions of the Royal Society of South Africa* **5:** 65–194.

Cockerell, T. D. A. 1905. Some Coccidae from the Philippine Islands. *Proceedings of the Davenport Academy of Sciences* **10:** 127–136.

Comstock, J. H. 1881. Report of the Entomologist. Part II. Report on scale insects. *Report of the Entomologist of the United States Department of Agriculture for the year 1880*: 276–349.

Cox, J. M. 1981. Identification of *Planococcus citri* (Homoptera: Pseudococcidae) and a description of a new species. *Systematic Entomology* **6:** 47–53.

—— 1983. An experimental study of morphological variation in mealybugs (Homoptera: Coccoidea: Pseudococcidae). *Systematic Entomology* **8:** 361–382.

—— 1987. Pseudococcidae (Insecta: Hemiptera). *Fauna of New Zealand* **11:** 1–228.

Cox, J. M. & Ben-Dov, Y. 1986. Planococcine mealybugs of economic importance from the Mediterranean Basin and their distinction from a new African genus (Hemiptera: Pseudococcidae). *Bulletin of Entomological Research* **76:** 481–489.

Cox, J. M. & Freeston, A. C. 1985. Identification of mealybugs of the genus Planococcus (Homoptera: Pseudococcidae) occurring on cacao throughout the world. *Journal of Natural History* **19:** 719–728.

Cox, J. M. & Wetton, M. N. (in press). Identification of the mealybug, Planococcus halli, commonly occurring on yams (*Dioscorea* sp.) in Nigeria and the West Indies. *Bulletin of Entomological Research.*

Danzig, E. M. 1977. On the nomenclature and distribution of some injurious scale insects (Homoptera, Coccoidea). *Entomologicheskoe Obozrenie* **56:** 99–102. [In Russian.]

—— 1980. Coccids of the far east of the USSR (Homoptera, Coccinea) with an analysis of the phylogeny of coccids of the world fauna. *Opredeliteli po Faune SSR* no. 124: 366 pp. [In Russian.]

—— 1986. New data on the systematics of Coccinea (Homoptera) of the USSR Fauna. *Vestnik Zoologii* **3:** 18–22. [In Russian with English summary.]

De Lotto, G. 1954. Three apparently new mealy bugs from Kenya. *Proceedings of the Royal Entomological Society of London* (B) **23:** 110–114.

—— 1961. New Pseudococcidae (Homoptera: Coccoidea) from Africa. *Bulletin of the British Museum (Natural History)* (Entomology) **10:** 209–238.

—— 1964. Observations on African mealy bugs (Hemiptera: Coccoidea). *Bulletin of the British Museum (Natural History)* (Entomology) **14:** 341–397.

—— 1967. The mealybugs of South Africa (Homoptera: Pseudococcidae), I. *Entomology Memoirs. Department of Agricultural Technical Services. Republic of South Africa* **12:** 1–28.

—— 1975. Notes on the vine mealybug (Homoptera: Coccoidea: Pseudococcidae). *Journal of the Entomological Society of Southern Africa* **38:** 125–130.

—— 1977. On some African mealybugs (Homoptera: Coccoidea: Pseudococcidae). *Journal of the Entomological Society of Southern Africa* **40:** 13–36.

Ezzat, Y. M. & McConnell, H. S. 1956. A classification of the mealybug tribe Planococcini (Pseudococcidae, Homoptera). *Bulletin. University of Maryland Agricultural Experiment Station* **A-84:** 1–108.

Fernald, M. E. 1903. A catalogue of the Coccidae of the world. *Bulletin of the Hatch Agricultural Experiment Station* **88:** 1–360.

Ferris, G. F. 1922. Two new Coccidae from Cyrenaica. *Bollettini del Laboratorio di Zoologia Generale e Agraria della R. Scuola Superiore d'Agricoltura. Portici* **16:** 207–210.

—— 1950. *Atlas of the scale insects of North America.* Series V. The Pseudococcidae (Part I). vii, 278 pp. Stanford, California.

—— 1954. Report on scale insects collected in China (Homoptera: Coccoidea). Part V. *Microentomology* **19:** 51–66.

Green, E. E. 1906. Entomological notes for the month. *Tropical Agriculturalist* **24:** 43–45.

—— 1911. On some Coccidae affecting rubber trees in Ceylon, with descriptions of new species. *The Journal of Economic Biology* **6:** 27–37.

Hambleton, E. J. 1935. Notas sobre Pseudococcinae de importancia economica no Brasil com a descripcao de quatro especies novas. *Archivos do Instituto Biologico. São Paulo* **6:** 105–120.

Hempel, A. 1900. As Coccidas Brazileiras. *Revista Museu Paulista. Sao Paulo* **4:** 365–537.

—— 1901a. Descriptions of Brazilian Coccidae. *The Annals and Magazine of Natural History* (7) **7:** 110–125.

—— 1901b. On some new Brazilian Hemiptera. Coccidae. *The Annals and Magazine of Natural History* (7) **8:** 388–391.

Kuwana, S. I. 1902. Coccidae (Scale Insects) of Japan. *Proceedings of the California Academy of Sciences* (3) Zoology **3:** 43–84.

Le Pelley, R. H. 1935. The common coffee mealy-bug of Kenya (Hem.: Coccidae). *Stylops* **4:** 185–188.

—— 1943a. The biological control of a mealybug on coffee and other crops in Kenya. *Empire Journal of Experimental Agriculture* **11:** 78–88.

—— 1943b. On Oriental mealybug (*Pseudococcus lilacinus* Ckll.) (Hemiptera) and its insect enemies. *Transactions of the Royal Entomological Society of London* **93:** 73–93.

Lichtenstein, J. 1870. Seance du 25 mai 1870. Annales de le Société Entomologique de France (4) **10:** l-li.

Mamet, J. R. 1939. Some new genera and species of Coccidae (Hemipt. Homopt.) from Mauritius. *Transactions of the Royal Entomological Society of London* **89:** 579–589.

—— 1959. Notes on the Coccoidea of Madagascar IV. *Memoires de l'Institut Scientifique de Madagascar* (E). **11:** 369–479.

Mann, W. M. 1922. Notes on a collection of West African Myrmecophiles. *Bulletin of the American Museum of Natural History* **45:** 623–630.

Marchal, P. 1908. Notes sur les cochenilles de l'Europe et du Nord de l'Afrique. *Annales de la Société Entomologique de France* 77: 223–309.

Maskell, W. M. 1897. Further coccid notes: with descriptions of new species, and discussion of points of interest. *Transactions and Proceedings of the New Zealand Institute* 19: 293–331.

McKenzie, H. L. 1967. *Mealybugs of California with taxonomy, biology and control of North American species (Homoptera: Coccoidea: Pseudococcidae).* viii 524 pp. Berkeley Los Angeles, California.

Morrison, H. 1920. The nondiaspine Coccidae of the Philippine Islands, with descriptions of apparently new species. *The Philippine Journal of Science* **17:** 147–202.

—— 1925. Identity of the mealybug described as *Dactylopius calceolariae* Maskell. *Journal of Agricultural Research* **31:** 485–500.

Nasonov, N. V. 1908. On some new coccids. *Ezhegodnik Zoologicheskago Muzeya Imperatorskoĭ Akademïi Nauk* **13:** 471–499. [In Russian.]

Nedzel'skii, A. 1869. One of the pests of fruit trees in Crimea *Zemeledelcheskaya Gazeta* **1869 (2):** 19–25, 36–38. [In Russian.]

Penzig, A. G. O. 1887. *Studi Botanici sugli Agrumi esulle Piante affini.* 590 pp. Rome.

Riley, C. V. 1888. Synonymy of the mealybug of the orange. *Insect Life* **1:** 118.

Risso, A. 1813. Mémoire. Sur l'histoire naturelles des orangers, bigaradiers, limettiers, cédradiers, limoniers ou citroniers, cultivés dans le department des Alpes-Maritimes. *Annales du Muséum d'Histoire Naturelles* **20:** 169–212, 401–431.

Rosen, D. & DeBach, P. 1977. Use of scale-insect parasites in Coccoidea systematics. *Research Bulletin. Virginia Polytechnic Institute and State University* **127:** 5–21.

Sasscer, E. R. 1912. Catalogue of recently described Coccidae -IV. *Bulletin. Bureau of Entomology. United States Department of Agriculture* Technical series **16:** 83–97.

Signoret, V. 1875. Essai sur les cochenilles ou gallinsectes (Homopteres-Coccides), 15, 16, 17 parties. *Annales de la Société Entomologique de France* **5:** 305–394.

Strickland, A. H. 1947. Coccids attacking cacao (*Theobroma cacao* L.) in West Africa, with descriptions of five new species. *Bulletin of Entomological Research* **38:** 497–523.

Tang, F. 1977. *The scale insects of horticulture and forestry of China.* 259 pp. Shenyang, Liaoning, China

Williams, D. J. 1958. The mealy-bugs (Pseudococcidae: Homoptera) described by W. J. Hall, F. Laing and A. H. Strickland from the Ethiopian Region. *Bulletin of the British Museum (Natural History)* (Entomology) **7:** 1–37.

—— 1960. A new species of *Planococcus* Ferris (Coccoidea: Homoptera) on yams in New Guinea. *Papua and New Guinea Agricultural Journal* **13:** 39–40.

—— 1982. The distribution of the mealybug genus *Planococcus* (Hemiptera: Pseudococcidae) in Melanesia, Polynesia and Kiribati. Bulletin of Entomological Research **72:** 441–455.

—— 1985. *Australian mealybugs.* 431 pp. London.

Zahradnik, J. 1959. Cervci-Coccinea, pp. 527–552. *In* Kratochvil, J. (*Ed.*), *Klic Zvireny CSR.* 3: 869. Praha.

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Bull. Br. Mus. nat. Hist. (Ent.) **58**(1): 79–130 Issued 25 May 1989

The Simuliidae (Diptera) of the Santiago onchocerciasis focus of Ecuador

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Synopsis Keys to the adults, larvae and pupae of the seven species of Simuliidae found in the Santiago onchocerciasis focus of Ecuador are provided. Full morphological descriptions of each of these stages are given for each species, together with notes on their taxonomy, distribution and biology. Three new synonyms are established.

INTRODUCTION

The simuliid fauna of Ecuador had been only superficially studied up until 1980 when the discovery of onchocerciasis in the north of the country (Arzube, 1981) emphasised the need for a systematic investigation of the family. Previous taxonomic work on Simuliidae in Ecuador was either of a preliminary nature, consisting of notes on and keys to the then poorly studied fauna in papers that also covered the medical importance of the family (Leon & Wygodzinsky, 1953a, b; Levi-Castillo, 1956), or of a more detailed revisionary nature on certain high altitude temperate climate species of the Andes (e.g. Wygodzinsky, 1971). No studies then existed on the fauna of the lowland tropical forests of northern Ecuador where onchocerciasis is now known to occur. This paper provides the necessary biosystematic data on the Simuliidae of the Santiago onchocerciasis focus that are prerequisites for future longitudinal entomological surveys aimed at providing baseline data for vector control. Only three of the seven species recorded in the Santiago onchocerciasis focus are significantly anthropophilic and two of these, *Simulium exiguum* and *S. quadrivittatum*, have been incriminated as vectors of *Onchocerca volvulus* by Shelley & Arzube (1985).

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All species found in the Santiago onchocerciasis focus belong to the genus *Simulium* and the subgeneric assignments conform to those published in the recent checklist of world blackflies (Crosskey, 1987).

Material examined and terminology

All the material studied from the Santiago onchocerciasis focus was collected in 1981 during investigations into the vector species of the disease. Details of collection sites and the biology and medical importance of the species in the area have already been given by Shelley & Arzube (1985); a summary of this information is given for each species in the current paper. Data on the precise location of the focus shown in Figs 1 and 2, its topography, climate and inhabitants, are given in Arzube (1982) and Guderian *et al.* (1983). Specimens from the 1981 collection and subsequent

Fig. 1 Distribution of onchocerciasis in Ecuador.

collections made in other regions of Ecuador with which this material has been compared are deposited in the British Museum (Natural History), London, U.K. and the Instituto Nacional de Hygiene y Medicina Tropical 'Leopoldo Izquieta Perez', Guayaquil, Ecuador. Material has been conserved in the following ways: larvae, pupae, individually reared adults with their corresponding pupal pelts and females from biting catches – in 80% alcohol; individually reared adults in association with their pupal pelts preserved in glycerine in small polypropylene phials, and females from biting catches – in pinned collection; all stages – on microscope slides mounted in Berlese mountant. Chromosomal preparations from larval silk glands of some of the species are stored on microscope slides with accompanying photographs of some of the karyotypes in the Diptera Section of the Entomology Department of the British Museum (Natural History); larval cadavers from which silk glands have been extracted are preserved in 80% alcohol and on microscope slides. With the increasing need for larval polytene chromosome analysis in taxonomic studies on Neotropical Simuliidae, preservation of samples of larvae in Carnoy's fixative must now become routine. Carnoy's fixative accentuates and in some cases alters the colour pattern of larvae compared to that seen in material preserved in alcohol. Where colour changes occur these are noted at the head of the larval descriptions. Descriptions of adult coloration for each

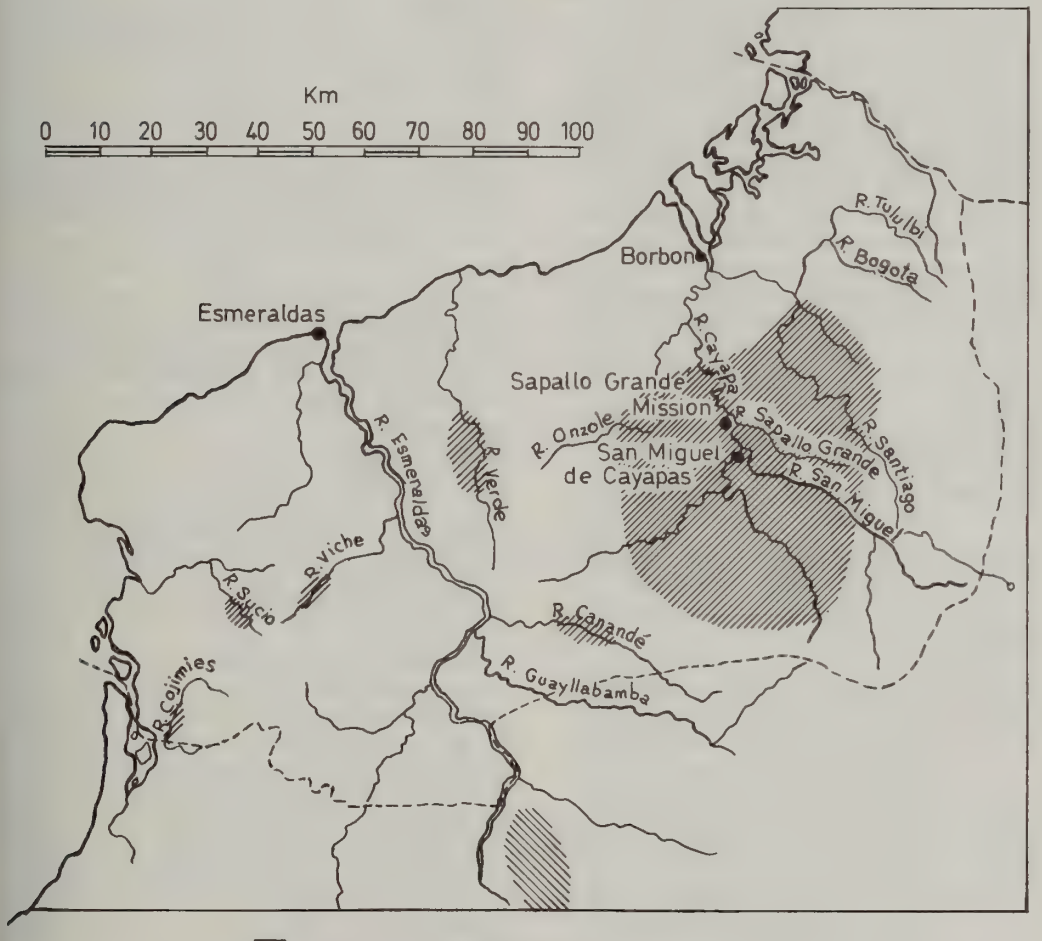


Fig. 2 The onchocerciasis foci of Esmeraldas Province, Ecuador.

species have been based on pinned specimens whereas photographs (Figs 138–153) are from alcohol preserved material prepared in the following way. Legs are removed from the body and directly mounted on a microscope slide in Berlese mounting medium. The wings are removed and discarded and the head, thorax and abdomen are placed in 'Cellosolve' for 12 hours, xylene for 6 hours and then air dried and mounted on a microscope slide using a drop of 'Araldite' epoxy resin. The specimens photographed have been preserved in alcohol for up to seven years and show little or no colour changes from pinned material. However, much of our alcohol material is teneral and hence full adult coloration, particularly of the legs, has not been attained. To obviate differences between descriptions and photographs of each species where possible, man-biting rather than reared females have been photographed.

Terminology of structures in adults, larvae and pupae referred to in the keys and species descriptions follows Crosskey (in press). General figures for male and female Simuliid genitalia not figured in that work may be found in Crosskey (1969); the terms coxite and style used by Crosskey are replaced with gonocoxite and gonostyle respectively. To avoid confusion with the less usual terminology found in many descriptions of the Latin American fauna the following equivalents are given (terms used in the present paper cited first):

nudiocular area (of female head) = fronto-ocular triangle;
paramere = endoparameral organ;
gonostyle = distimere;
gonocoxite = basimere.

The following acronyms are used for depositories of specimens referred to in this paper.

BMNH British Museum (Natural History), London, U.K.
DBAT Dipartimento di Biologia Animale, Universita di Torino, Torino, Italy
DDSV Seccion de Oncocercosis, Division de Dermatologia Sanitaria, Villa de Cura, Aragua State, Venezuela
DERM Laboratorio de Entomologia de la Division de Endemias Rurales, Maracay, Aragua State, Venezuela
INHMT Instituto Nacional de Hygiene y Medicina Tropical 'Leopoldo Izquieta Perez', Guayaquil, Ecuador
IOC Instituto Oswaldo Cruz, Rio de Janeiro, Brazil
MCZH Museum of Comparative Zoology, Harvard, U.S.A.
MLP Museo La Plata, La Plata, Argentina
MNHN Muséum National d'Histoire Naturelle, Paris, France
STMPR Department of Microbiology, School of Medicine, School of Tropical Medicine, San Juan, Puerto Rico
USNM United States National Museum, Washington, D.C., U.S.A.
ZM Zoologisches Museum der Humboldt Universitaet, Berlin, West Germany

Acknowledgements. We are indebted to the UNDP/World Bank/WHO under their Special Programme for Research and Training in Tropical Diseases, and the Pan American Health Organization for financial assistance, to Dr V. Reyes, Director of the 'Servicio Nacional de Erradicacion de Malaria (SNEM), Ministerio de la Salud Publica', Ecuador, for providing river transport, and to USAID for a visit to the BMNH by the second author. Drs J. Alarcon & E. Gomez and Messrs R. Llerena, I. Mera and A. Villavicencio are gratefully acknowledged for their technical assistance. Drs L. Matile, B. V. Peterson and E. O. Wilson kindly loaned specimens from the collections of the MNHN, USNM and MCZH respectively, and Dr R. W. Crosskey made valuable suggestions that have been incorporated in this paper. Miss S. Allington provided the illustrations and Mr P. York the photographs

SYSTEMATICS

Keys to the simuliid species of the Santiago onchocerciasis focus

Females

1 Scutum orange 2
– Scutum black 4

2 Scutum with white pruinose pattern dorsally. Abdomen without yellow tergites 3
– Scutum without white pruinose pattern dorsally. Abdomen with first three (rarely four) tergites yellow (Fig. 141). [Zoophilic] ..... ***lewisi***

3 Scutum with pair of submedian greyish white bands running from anterior border for four fifths of scutal length. Postnotum black with silver pruinosity. Abdomen with dorsal chequerboard pattern of prominent black markings on greyish background (Fig. 142). [Anthropophilic] ..... ***escomeli***
– Scutum with pair of submedian white pruinose comma-shaped bands beginning at posterior border of humeri and running half length of scutum. Postnotum orange. Abdomen dark brown with anterior segments orange (Fig. 140). [Mainly zoophilic] ***bipunctatum***

4 Scutum velvet-black with silver pruinose pattern formed by a pair of submedian longitudinal silver pruinose bands reaching silver pruinose hind margin and a pair of sublateral silver pruinose bands. Abdomen black dorsally with transverse silver pruinose bands

on segments of anterior three-quarters (Fig. 145). [Anthropophilic] ..... ***quadrivittatum***
– Scutum shiny black without silver pattern. Abdomen black without transverse silver pruinose bands .. 5

5 Scutal hairs yellowish white. Legs mainly dark; fore tarsi dilated (Fig. 144). Basal section of wing vein *R* with two or three irregular rows of hairs; *Sc* with single row of hairs (Fig. 41). [Zoophilic] ***mexicanum***
– Scutal hairs golden or green (depending on light incidence). Legs mainly pale; fore tarsi not dilated (Figs 138, 139). Basal section of wing vein *R* and *Sc* without hairs. 6

6 Paraproct with long anterior process (Fig. 55). [Anthropophilic] ..... ***exiguum***
– Paraproct with short anterior process (Fig. 56). [Zoophilic] ..... ***gonzalezi***

Males

1 Head dichoptic (Fig. 10) ..... ***gonzalezi***
– Head holoptic (Figs 8, 11) 2

2 Scutum orange or brown. Scutellum orange or yellow 3
– Scutum and scutellum black 5

3 Scutum orange or brown with a pair of silver or black submedian bands in anterior half. Postnotum orange or black 4
– Scutum orange without dorsal ornamentation. Postnotum black (Fig. 149) ..... ***lewisi***

4 Scutum orange with silvery white pruinose submedian bands touching anterior border (most obvious with anterior illumination). Postnotum orange (Fig. 148). Vestiture of scutum of evenly distributed black hairs. Basal section of wing vein *R* with single row of hairs ..... ***bipunctatum***
– Scutum orange to mid-brown with silver pruinose submedian bands touching anterior border using anterior illumination; bands comma-shaped and black, not touching anterior scutal border with posterior illumination. Postnotum black with grey pruinosity (Fig. 150). Vestiture of scutum of evenly distributed golden hairs. Basal section of wing vein *R* bare. ..... ***escomeli***

5 Scutum with a pair of silver pruinose submedian cunae in anterior third of scutum touching anterior border (Fig. 153) ..... ***quadrivittatum***
– Scutum without ornamentation 6

6 Scutum greyish black with velvet-black median line extending along its entire length; anterior and posterior scutal borders not pruinose. Scutum with dense vestiture of long-brass coloured setae. Legs mainly black; tarsi broad and flattened (Fig. 152). Large robust fly, 3.0–4.5 mm long (preserved in alcohol) ..... ***mexicanum***
– Scutum velvet-black; anterior and posterior scutal borders with silver pruinosity. Scutum with dense vestiture of short golden setae with green reflections. Legs mainly yellow or light brown with narrow unflattened tarsi (Figs 146, 147). Small fly 1.3–2.1 mm long (preserved in alcohol) 7

7 Femur of mid leg dark brown to black (Fig. 147). ***gonzalezi***
– Femur of mid leg yellow (Fig. 146) ..... ***exiguum***

Pupae

Gill with six filaments (Fig. 110) ..... ***gonzalezi***
– Gill with more than six filaments 2

2 Gill with twelve filaments (Fig. 115) .. ***mexicanum***
– Gill with eight filaments 3

3 Cocoon white to light brown, thick walled and with a longitudinal dorsal ridge. Gill with most distal bifurcations of dorsal and median primary branches at mid point (Fig. 106) ..... ***lewisi***
– Cocoon brown to grey, thin-walled and without dorsal ridge. Most distal bifurcations of dorsal and median primary branches within basal third of gill 4

4 Gills longer than length of ventral surface of cocoon and with spaced secondary branching (Fig. 116) ***quadrivittatum***
– Gills shorter than length of ventral surface of cocoon and with secondary branches of dorsal and median primary branches arising close to one another .. 5

5 Gill with secondary branching of all primary gill branches in basal eighth (Fig. 112) ... ***bipunctatum***
– Gill with most distal secondary branches of median and ventral primary branches within basal sixth to third 6

6 Abdominal sternite IV with 2 + 2 fine hairs on posterior margin ..... ***exiguum***
– Abdominal sternite IV with 1+1 outer simple or bifid hooks and 1+1 inner fine hairs ..... ***escomeli***

Mature larvae

1 Body length 6.9–9.7 mm ..... ***mexicanum***
– Body length 2.8–5.8 mm 2

2 Anterior abdominal segments white to grey with two prominent dark bands 3
– Anterior abdominal segments white to grey with a pale or dark band on each segment 4

3 Postgenal cleft small and pointed anteriorly; postgenal bridge as long as hypostomium (Fig. 137). Ventral papillae well-developed (Fig. 122) ***quadrivittatum***
– Postgenal cleft large and rounded anteriorly; postgenal bridge about one-tenth the length of hypostomium (Fig. 134). Ventral papillae absent or very small (Fig. 119) ..... ***lewisi***

4 Abdominal marking dark and very prominent .. 5
– Abdominal marking light and indistinct 6

5 Head capsule without pattern (occasionally a positive head pattern or an amorphous darker area in region of head spots occurs) (Fig. 123) .. ***exiguum***
– Head capsule with negative pattern (occasionally without pattern) (Fig. 124) ..... ***gonzalezi***

6 Postgenal bridge as long as hypostomium (Fig. 135). Ventral papillae absent (Fig. 120). Anal gills usually with three simple lobes but outer pair sometimes with up to two additional secondary lobules ***escomeli***

– Postgenal bridge one-third the length of the hypostomium (Fig. 133). Ventral papillae small (Fig. 118). Anal gills with 6–8 secondary lobules on each primary lobe. ..... ***bipunctatum***

Simulium (Notolepria) exiguum Roubaud

(Figs 3, 5, 7, 8, 12–14, 17, 21, 23, 24, 25, 31, 37, 43, 49, 55, 62, 69, 75, 76, 90, 103, 110, 117, 123, 131, 138, 146)

Simulium exiguum Roubaud, 1906: 108. LECTOTYPE ♀, VENEZUELA: Haut Sarare, 1899 (*F. Geay*) (MNHN), here designated. [examined]

Simulium glaucophthalmum Knab, 1914b: 123. Holotype ♀, PERU: Santa Clara, iv.1914 (*C. H. T. Townsend*) (USNM Cat. No. 18494) [examined]. [Synonymy by Wygodzinsky, 1951: 214.]

Simulium delpontei Paterson & Shannon, 1927: 742. Holotype ♀, ARGENTINA: Salta Province, Embarcacion, 4.v.1926 (*Paterson, Shannon & Shannon*) (depository unknown). [Synonymy by Wygodzinsky, 1951: 214.]

DESCRIPTION. *Female*. General body colour black. Body length (alcohol preserved specimens) 1.8–2.7 mm (n = 24), wing length 1.4–2.0 mm (n = 21), wing width 0.7–0.9 mm (n = 19).

Head dichoptic (Fig. 7) with dark red eyes showing green highlights; nudiocular area absent (Fig. 25). Frons, clypeus and occiput black with silver pruinosity. Mouthparts orange-brown. Antennae dark brown with scape, pedicel and first flagellomere orange-brown. Cibarium unarmed (Fig. 31).

Scutum and humeri greyish black with faint silver pruinosity; one median and a pair of posteriorly divergent submedian darker black lines running along whole length of scutum (best seen in specimens devoid of setae and with illumination perpendicular to specimen); scutum also with small velvet-black spot adjoining paranotal folds (= paratergites). Paranotal folds black with silvery grey pruinosity. Scutum with numerous short adpressed dark setae and discrete groups of short flattened brass-coloured setae with greenish reflections (Fig. 138). Pleural region silvery grey pruinose. Scutellum greyish black and faintly pruinose, its vestiture comprised of golden setae longer than those on scutum and a single row of black bristles on posterior margin. Postnotum silvery grey pruinose.

Subcostal wing vein and basal sector of radius bare (Fig. 37). Costal base tuft of dark hairs.

Legs yellow to light brown, except fore tarsi, mid and hind coxae, hind femora and distal three-fourths of hind tibiae black. All femora and tibiae with scales (Fig. 3). Proportions of legs as in Fig. 138. Claws curved and slender, without basal tooth on fore and mid legs but with poorly developed tooth on hind leg (Fig. 43). Halteres pale yellow with light brown stem.

Abdominal tergites shiny brownish black with silver pruinosity on second segment (Fig. 138). Tergal plates well-developed, pattern as in Fig. 4. Sternites brownish black; genitalia light brown. Eighth sternite highly sclerotised with a group of 8–12 stout setae in each sclerotised portion (Fig. 49); gonopophyses small, sclerotised on inner margin, glabrous. Cerci hemispherical, light brown; paraprocts broadly rectangular with pointed anteriorly directed process (Fig. 55). Genital fork (Fig. 62) slender, with sclerotised anteriorly directed processes and stem. Spermatheca oval, highly sclerotised, with no external sculpturing and spicules of inner surface obscured by sclerotisation; width of membranous area of insertion of spermathecal duct large, about half maximum width of spermatheca (Fig. 5).

Male. General body colour black. Body length (alcohol preserved specimens) 1.9–2.1 mm (n = 6), wing length 1.5–1.7 mm (n = 5), wing width 0.7–0.8 mm (n = 5).

Head holoptic (Fig. 8) with dark red eyes; lower, smaller facets with greenish reflections. Clypeus black with silver pruinosity, other head coloration as in female.

Scutum and humeri velvet-black with anterior and posterior margins and anterior two-thirds of lateral margin silver pruinose (Fig. 146). Paranotal folds velvet-black with silvery grey pruinosity. Scutum covered in numerous, short, adpressed, light brown setae interspersed amongst groups of brilliant gold, scale-like setae. Coloration and setation of pleural region, scutellum and postnotum as in female except scale-like setae on scutellum brilliant gold.

Wing venation, leg coloration (Fig. 146) and haltere coloration as in female.

Abdominal tergites velvet-black, basal fringe dark brown with few long hairs. Silver ornamentation as follows: tergites II and VI all silver except sometimes in median area on VI; tergite VII all silver except for median area, some specimens show a pair of lateral silver pruinose patches on posterior margin of tergite VIII. Tergite IX shiny black (Fig. 146). Sternites grey with well-developed velvet-black sternal plates on segments II–VIII (Fig. 6). Genitalia brownish black. Gonocoxite subrectangular, gonostyle small, subtriangular, one-third as long as gonocoxite and with small distal spine (Fig. 69). Ventral plate with reduced basal arms, lightly sclerotised, triangular

with small keel, hairs short, diffuse and mainly occurring around median keel (Figs 75, 76). Median sclerite subrectangular with deep apical incision (Fig. 90). Paramere with several apical spines (as shown in Fig. 97 for *S. gonzalezi*).

Pupa. Cocoon length dorsally 1.6–2.6 mm, ventrally 2.2–3.2 mm; pupa length 1.7–2.3 mm; gill length 1.3–2.1 mm (n = 27).

Cocoon slipper-shaped, mid to dark brown; rim of aperture dark brown, reinforced and without central protuberance (Fig. 103). Cocoon composed of elastic, amorphous substance interwoven with fibres. Gill light brown with eight forwardly directed slender filaments arranged in the vertical plane (Fig. 110), main trunk giving rise to three primary branches, ventral with two filaments and median and dorsal each with three filaments; ventral branch with bifurcation in basal fourth of gill, median branch with first bifurcation in basal fourth and second bifurcation in basal third of gill; dorsal branch with first bifurcation basally at junction of median and dorsal primary branches and second bifurcation within basal fourth of gill; filaments slender with crenate margins and rounded distally, their surfaces covered in fine spicules (Fig. 12). Head (frontoclypeus) with 2 + 2 frontal trichomes of which the more dorsal pair is simple and poorly developed and the more ventral pair well-developed and 2–5 branched, and 1 + 1 well-developed facial trichomes with 2–5 branches; surface of head covered with platelets (Figs 13, 14). Thorax with 5 + 5 antero-dorsal, well-developed trichomes of 2–5 branches. Surface of thorax covered with platelets which are more densely distributed on anterior half (Fig. 17). Abdominal tergite II with 4 + 4 simple hairs in a line on posterior border of segment, III–IV with 4 + 4 simple hooks, VI–IX with patches of poorly developed spine combs on antero-lateral margins, IX with 1 + 1 strong, unbranched spines (Fig. 19); sternite IV with 1 + 1 simple hairs, V with 2 + 2 bifid or trifid hooks, VI and VII with 2 + 2 hooks, the inner pairs being bifid or trifid and the outer pairs simple; 1 + 1 patches of poorly developed spine combs on postero-lateral borders of sternites IV–VIII (Fig. 20).

Mature larva. Body length 3.6–4.4 mm (n = 33). Width of head capsule 0.4–0.5 mm (n = 32). Body usually white with greyish brown markings (Fig. 117), occasionally almost completely white and showing only indistinct grey pigmentation. Coloration in Carnoy's fixative is similar except that the banding patterns are more distinct. Body form as in Fig. 117.

Head yellow with head spots concolorous; occasional specimens with positive head spot pattern as in Fig. 123 or with an amorphous dark area in head spot region that obscures the spots. Head capsule with few, randomly distributed setae on all surfaces. Postgenal cleft as wide as long, rounded anteriorly; postgenal bridge about half as long as hypostomium (Fig. 131). Hypostomium with strongly pigmented anterior margin and nine apical teeth: corner teeth large and blunt, median tooth less developed but larger than subequal intermediate teeth; 4–5 lateral serrations with hindmost about level with first hypostomial seta; 1 + 1 groups of four hypostomial setae lying parallel to lateral margins of hypostomium; surface of hypostomium with a few short setae (Fig. 21). Antennae long, unpigmented with segment ratios 23 : 10 : 12. Mandible (Fig. 23) with first three comb teeth decreasing in size posteriorly and two mandibular serrations of which the anterior is larger. Maxillary palp about twice as long as breadth at base. Cephalic fan with 30–43 rays (n = 10).

Thorax white with grey ring around anterior region and grey pattern dorsally of variable form that almost covers whole area, ventrally with two or three central patches of grey chromatocytes posterior to proleg. Cuticle with occasional small setae dorsally, glabrous ventrally. Proleg plates lightly sclerotised and with about six processes. Pupal respiratory histoblast dark brown, claviform.

Abdomen white with a single complete black or grey ring on each of the four anterior narrow segments; posterior segments grey or black dorsally, white with variable scattered black chromatocytes ventrally. Ventral nerve cord black. Ventral papillae absent. Cuticle with minute hairs dorsally in dark areas, ventral surface glabrous. Anterior perianal area with a group of fine spines. Anal sclerite well sclerotised with posterior arms extending to twelfth row of posterior circlet hooks. Posterior circlet with 70–78 rows of 2–14 hooks (n = 8). Anal gill trilobed, each lobe with 6–8 long finger-like lobules (Fig. 24).

Material Examined

Lectotype ♀, paralectotypes 5 ♀ of *S. exiguum*, **Venezuela**: Sarare, 1899 (*F. Geay*) (BMNH, MNHN). Holotype ♀ of *S. glaucophthalmum*, **Peru**: Santa Clara, 1914 (*C. H. T. Townsend*) (USNM).

Argentina: 3 ♀, Jujuy, xii.1938 (*W. C. Paterson*) (BMNH).

Bolivia: 2 ♀, Covende, 1921–22 (*W. M. M. Mann*) (BMNH); 1 ♀, HuachiBeni, viii.1921–22 (*W. M. M. Mann*) (BMNH).

Brazil: Roraima Territory: 1 ♀, Posto Meva, Rio Auaris, 3.iv.1977 (*R. R. Pinger*) (BMNH); 1

♀, 15 ♀ 6 ♂ (ex pupae), Catrimani Mission, Rio Catrimani, 9.i.1977 and 12, 13.i.1979 (*A. J. Shelley*, and *A. J. Shelley & A. P. A. Luna Dias*) (BMNH); 1 ♀ 1 ♂ (ex pupae), Rio Uraricoeira, 20.i.1979 (*A. J. Shelley & A. P. A. Luna Dias*) (BMNH); 3 ♀ 2 ♂ (ex pupae), Northern Perimeter Road, Rio Agua Preta, 18.xi.1980 (*A. J. Shelley & A. P. A. Luna Dias*); 1 ♀ 1 ♂ (ex pupae), Mucajai Mission, Rio Mucajai, 6.i.1977 (*A. J. Shelley*) (BMNH); 1 ♂, Normandia, Igarapé Inamaru, 3.xii.1980 (*A. J. Shelley & A. P. A. Luna Dias*) (BMNH); 1 ♀, 1 ♀ 5 ♂ (ex pupae), Vila Pereira, Rio Surumu, 25, 26.xi.1980 (*A. J. Shelley & A. P. A. Luna Dias*) (BMNH); 2 ♀ 2 ♂ (ex pupae), nr Bonfim, Rio Arraia, 3.xii.1980 (*A. J. Shelley & A. P. A. Luna Dias*); Amazonas State: 11 ♀, Mission Post, Rio Toototobi, 16.viii. and 24, 25.x.1976 (*R. R. Pinger*) (BMNH); 6 ♀, Rio Ituxi, v.1978 (*D. Roberts*) (BMNH); 6 ♀ 3 ♂ (ex pupae), Mato Grosso, Rio Aripuana, 29.vi.1978 (*J. D. Charlwood*) (BMNH).

Colombia: Sierra Nevada de Santa Marta: 3 ♀, Ariguani, 20.xii.1963 (*J. P. Lee-Potter*) (BMNH); 1 ♀, Meollaca, 22.xii.1963 (*J .P. Lee-Potter*), 2 ♀, Valledupar, 15.i.1963 (*J. P. Lee-Potter*) (BMNH); 2 ♀, Department of Valle, Tunselas, 16.iii.1977 (*J. Ardila*) (BMNH).

Ecuador: numerous man-biting females, reared adults, pupae and larvae from the following localities in the Santiago onchocerciasis focus in Esmeraldas Province: R. Cayapa, San Miguel de Cayapas, 18–21.vi.1981 (*A. J. Shelley & M. Arzube*) (BMNH, INHTM); R. Grande (Cayapa), Viruela and Calle Mansa, 26–27.v.1981 (*A. J. Shelley & M. Arzube*) (BMNH, INMHT); R. Sapallo Grande, Tumbaviro, 18.vi.1981 (*A. J. Shelley & M. Arzube*) (BMNH, INHTM); numerous man-biting females, reared adults and larvae from the Canandé peripheral onchocerciasis focus in Esmeraldas Province, R. Canandé, Naranjal, 25.ix.1983 and 21–24.vi.1985 (*A. J. Shelley & M. Arzube*) (BMNH, INHMT); 1 ♀, 1 ♀ (ex pupa), 1 larva, Esmeraldas Province, nr Concordia, road to Puerto Quito, R. Caoni, 24.ix.1983 (*A. J. Shelley & M. Arzube*) (BMNH); 2 ♀ 1 ♂ (ex pupa), nr Concordia, road to Puerto Quito, Rio Salazar, 28.ix.1983 (*A. J. Shelley & M. Arzube*) (BMNH, INMHT); 5 ♀ 3 ♂ (ex pupae), nr Concordia, road to Puerto Quito, R. Blanco, 28.ix.1983 (*A. J. Shelley & M. Arzube*) (BMNH); 1 ♀ (ex pupa), Santo-Domingo-Esmeraldas road, Rio Sapotal, 26.ix.1983 (*A. J. Shelley & M. Arzube*) (BMNH); 1 ♀, Imbabura Province, Salinas road, R. Tahuando, 8.ix.1983 (*A. J. Shelley & M. Arzube*) (BMNH); 3 ♀, 5 ♀ 3 ♂ (ex pupae), Salinas-Lita road, San Juan del Hacha, R. Mira, 11.ix.1983 (*A. J. Shelley & M. Arzube*) (BMNH); 1 ♀ (ex pupa), Salinas-Lita road, R. San Pedro, 11.ix.1983 (*A. J. Shelley & M. Arzube*) (BMNH); 13 ♀, 16 ♀ 12 ♂ (ex pupae), Napo Province, nr Lago Agrio, Rio San Miguel, 9.xii.1982 (*A. J. Shelley & M. Arzube*) (BMNH); 1 ♀, nr Lago Agrio, Posto 19, R. Tarapa, 9.xii.1982 (*A. J. Shelley & M. Arzube*) (BMNH); 1 ♀, nr Lago Agrio, Rio Teteye, 9.xii.1982 (*A. J. Shelley & M. Arzube*) (BMNH); 15 ♀, 8 ♀, 6 ♂ (ex pupae), nr Lago Agrio, Dureno, R. Aguarico, 10–13.xii.1982 (*A. J. Shelley & M. Arzube*) (BMNH, INHMT); 8 ♀, nr Tena, Misahualli, R. Napo, 7.vi.1985 (*A. J. Shelley & M. Arzube*) (BMNH); 6 ♀, 1 ♀ (ex pupa), El Oro Province, Machala-Naranjal road, canal de riego, Rio Bucay, 12.vi.1984 (*A. J. Shelley & M. Arzube*) (BMNH); 4 ♀, Machala-Uzcurume road, nr Pasaje, Rio Guesha, 20.vi.1984 (*A. J. Shelley & M. Arzube*) (BMNH); 1 ♀ (ex pupa), Machala-Uzcurume road, near Pasaje, Rio Jubones, 20.vi.1984 (*A. J. Shelley & M. Arzube*) (BMNH); 2 ♀, 4 ♀ 2 ♂ (ex pupae), Machala-Pinas road, Rio Carne Amarga, 21.vi.1984 (*A. J. Shelley & M. Arzube*) (BMNH); 2 ♀, Pastaza Province, Tena-Puyo road, Rio Mira Valle, 8.vi.1985 (*A. J. Shelley & M. Arzube*) (BMNH); 1 ♀, Puyo, Shell-Mera road, confluence of Rios Alpayacu and Pastaza, 10.vi.1985 (*A. J. Shelley & M. Arzube*) (BMNH); 6 ♀, 5 ♀ 2 ♂ (ex pupae), Cotopaxi Province, Quevedo-La Mana-Pilalo road, Rio San Pablo, 8.vi.1984 (*A. J. Shelley & M. Arzube*) (BMNH, INHMT); 1 ♂ (ex pupa), Quevedo-La Mana-Pilalo road, Recinto Beles, Rio San Pablo, 8.vi.1984 (*A. J. Shelley & M. Arzube*) (BMNH); 6 ♀, 1 ♂ (ex pupa), Manabi Province, Santo Domingo-El Carmen road, Rio Suma, 7.vi.1984 (*A. J. Shelley & M. Arzube*) (BMNH); 2 ♀, Los Rios Province, Babahoyo-Montalvo road, Rio Cristal, 10.vi.1984 (*A. J. Shelley & M. Arzube*) (BMNH); 3 ♀, Bolivar Province, Babahoyo-Balzapamba-Aguaranda road, Rio Chanpiaco, 10.vi.1984 (*A. J. Shelley & M. Arzube*) (BMNH); 39 ♀, 2 ♀ 2 ♂ (ex pupae), Guayas Province, Naranjal-Machala road, Via Cooperativa 11 de Agosto, Rio Bucay, 19.vi.1984 (*A. J. Shelley & M. Arzube*) (BMNH); 14 ♀, 2 ♀ (ex pupae), Loja Province, Loja-La Toma road, Hacienda Monterey, Rio Guayabal, 23.vi.1984 (*A. J. Shelley & M. Arzube*) (BMNH).

Venezuela: numerous man-biting females from the Caripe onchocerciasis focus, Monagas State, San Antonio de Maturin (nr Caripe) and Caripe area, 7.iv.1981 and iv.1981 (*D. J. Lewis*) (BMNH); 3 ♀ 5 ♂ (ex pupae), Yaracuy State, Rio Yaracuy (no collection date) (*J. Ramirez Perez*) (BMNH); 1 ♀ with associated pupal case, Miranda State, Tacata (no collection date) (*J. Ramirez Perez*) (BMNH); 1 ♀ 2 ♂ (ex pupae),

Trujillo State, Carache (no collection date) (*J. Ramirez Perez*) (BMNH).

TAXONOMIC DISCUSSION. *Simulium exiguum* was described by Roubaud from a series of females (one specimen pinned and an undisclosed number preserved in alcohol) sent from Sarare [presumably the upper reaches of the R. Sarare in Arauca State in northern Venezuela, where *S. exiguum* is commonly found today] by F. Geay. No type designations were made in the paper so the specimens have syntype status. Vargas (1945) incorrectly refers to their status as a type [= holotype] in the MNHN and a probable paratype in the BMNH. Six pinned specimens from the original material have been located in the BMNH and MNHN, each bearing a printed label of the Paris Museum as follows: 'Museum Paris, Venezuela, Sarare, Geay 1899'. One of the five specimens in the MNHN bears a 'type' label and a handwritten label with the following details '*S. exiguum* Roubaud n.sp. Bull.Mus. 1906'. This specimen is in relatively good condition, is here designated lectotype and has been labelled accordingly. The other four specimens in the MNHN appear to have been recovered from alcohol and have been labelled as paralectotypes. The single specimen in the BMNH had been previously recovered from alcohol and although in poor condition is recognisable as *S. exiguum*. It bears two labels in Austen's hand indicating the collection locality and that it was donated by Roubaud, and it has now been labelled as a paralectotype.

In Wygodzinsky's revision (1951) of *S. exiguum* two nominal species, *S. glaucophthalmum* Knab collected in Peru and *S. delpontei* Paterson & Shannon from Argentina, are synonymised with *S. exiguum*. His synonymy of *S. glaucophthalmum* was based on an examination of types and Knab's description (1914b) but no reasons were given for the synonymy of *S. delpontei* with *S. exiguum*. We here confirm the former synonymy following dissection of the *S. glaucophthalmum* holotype and comparison of its paraprocts with those of *S. exiguum*. Although Paterson & Shannon's description (1927) of *S. delpontei* clearly indicates it to be within the subgenus *Notolepria* its synonymy with *S. exiguum* or the closely related *S. gonzalezi* or *S. paraguayense* may only be clarified once the form of its paraproct is known. Coscaron & Wygodzinsky (1975) continue to cite *S. delpontei* as a synonym of *S. exiguum* in a paper devoted to comparing the latter with *S. paraguayense*. We also recommend that the value of the characters, principally the female paraproct, used for the separation of *S. paraguayense, S. exiguum* and *S. gonzalezi* are investigated in conjunction with chromosomal analyses in 'genetically monomorphic' populations in order to clarify the taxonomic status of these three species.

Simulium exiguum is one of the more commonly encountered anthropophilic South American simuliids and hence has been well described and cited in numerous publications. The most complete taxonomic works on the species are Wygodzinsky (1951) and Coscaron & Wygodzinsky (1975). *Simulium exiguum* is the type species of the subgenus *Notolepria* and is closely related to *S. paraguayense* from southern South America, from which it is distinguished by adult leg coloration and the morphology of the male and female genitalia (Coscaron & Wygodzinsky, 1975). Another close relative, *S. gonzalezi* Vargas & Diaz Najera, occurs sympatrically in Ecuador with *S. exiguum* from which it may be distinguished by adult leg coloration, the form of the female paraproct and the number of pupal gill filaments. Takaoka (1983) confirmed Dalmat's finding in 1955 that in Guatemala this latter character is variable within *S. gonzalezi* and cannot therefore be used for accurate species determination there. Similar observations on the form of the paraproct for distinguishing *S. exiguum* from *S. gonzalezi* were made by Lewis & Lee-Potter (1964). They noted differences in the paraproct of *S. exiguum* from the Sierra Nevada de Santa Marta in northern Colombia compared with typical *S. exiguum* from northern Venezuela. Lewis (1963) also refers to the presence of eight-filamented pupae of *S. gonzalezi* in Antigua but no material has been found in the BMNH collections. In Ecuador separation of *S. exiguum* and *S. gonzalezi* has been based on the form of the paraproct in females in conjunction with the number of filaments in the gill of the pupa. No variation in gill filament number was observed, pupae with eight-filamented gills always producing females with *S. exiguum* type paraprocts and those with six filaments females with *S. gonzalezi* type paraprocts. Adult females collected biting man and horses were identified as *exiguum* or *gonzalezi* based on paraproct form, and similar identifications of males were based on the gill form of pupae from which they were reared.

Only male *S. exiguum* with holoptic heads were recorded in the Santiago onchocerciasis focus but a dichoptic form occurs in Venezuela (Vargas & Diaz Najera, 1953b; Lewis 1963) and Darien Province, Panama (material collected by Dr J. Petersen and examined by senior author).

The recent discovery (Procunier *et al.*, 1985 and Procunier, pers. comm.) that *S. exiguum* is a complex of at least four sibling species in Ecuador now suggests the need for integrated morphological

and cytological studies when investigations on the biology and medical importance of the sibling species in South America are made.

DISTRIBUTION. In Ecuador *S. exiguum* is found in most provinces on both the east and west of the Andean cordillera. It occurs at both the main onchocerciasis focus in the Santiago river basin and at the peripheral focus at the R. Canandé.

Simulium exiguum occurs in the following South American countries: Argentina, Bolivia, Brazil, Colombia, Peru and Venezuela. It has also been recently collected in southern Panama (Dr J. Petersen, pers. comm.). Records of its occurrence in other Central American countries, especially Guatemala and Mexico, need to be verified because in many cases these refer to *S. gonzalezi* (Vargas & Diaz Najera, 1953b; Dalmat, 1955; Takaoka, 1983). Further details of its distribution and bionomics may be obtained in Shelley (in press b).

BIOLOGY. In Ecuador *S. exiguum* is the most common man-biting species in the lowland tropical forests of the eastern and western slopes of the Andes, where, typically at altitudes of 100–500 m, high biting rates of up to 2200 flies/man/day occur in some localities (Procunier *et al.*, 1985; Shelley & Arzube, 1985, unpublished data); in these areas horses, when present, are also favoured as a blood source. Similar host preferences have been noted for this species in northern Venezuela in an area where it is a suspected sporadic vector of onchocerciasis (Lewis & Ibañez de Aldecoa, 1962) and in Colombia where it attacks man, horses and cattle in large numbers (Guttman, 1972), showing a preference for animal hosts in some localities (Trapido *et al.*, 1971). *Simulium exiguum* bites man in large numbers in Argentina (Coscaron & Wygodzinsky, 1975) but in contrast it may be almost entirely zoophilic in some localities in northern Brazil (Shelley, 1988). In Bolivia it has been recorded biting tapirs (Vargas & Diaz Najera, 1953b).

Apart from being a biting nuisance, *S. exiguum* is a primary vector of onchocerciasis in Ecuador (Shelley & Arzube, 1985) and Colombia (Tidwell *et al.*, 1980) and a suspected sporadic vector in northern Venezuela (Lewis & Ibañez de Aldecoa, 1962). A review of its biology in relation to onchocerciasis transmission in Latin America may be found in Shelley (1988). In Colombia, *S. exiguum* is also suspected of being involved in the transmission of Venezuelan Equine Encephalitis (Sanmartin *et al.*, 1973), although more recent work (Homan *et al.*, 1985) showing no viral replication in *S. metallicum* Bellardi and *S. mexicanum* also suggests that *S. exiguum* may only be involved in mechanical transmission.

Simulium exiguum favours open, sunlit rivers from 5–100 m wide for breeding grounds in Ecuador; larvae are found on fallen leaves and submerged tree branches in shallow shingle beds as well as in deeper parts of the river. Large rivers are the breeding sites of this species in other countries of South America (Coscaron & Wygodzinsky, 1975).

Simulium (Notolepria) gonzalezi Vargas & Diaz Najera

(Figs 9–11, 56, 63, 77–79, 91, 97, 104, 111, 124, 132, 139, 147)

Simulium gonzalezi Vargas & Diaz Najera, 1953b: 235. Syntypes ♀, ♂ and pupae, MEXICO and GUATEMALA (more precise information on localities, collection date, collectors and depository not given).

DESCRIPTION. *Female*. General body colour black. Body length (alcohol preserved specimens) 1.5–2.6 mm (n = 44), wing length 1.2–1.7 mm (n = 22), wing width 0.6–0.8 mm (n = 20).

Coloration and morphology as in *S. exiguum* except femora and inner surface of tibiae of mid leg and coxae of fore leg brownish black (Fig. 139). Tergal plates wider than in *S. exiguum* and paraproct with short anteriorly directed process (Fig. 56).

Male. There are two forms of the male: the predominant dichoptic form (Fig. 10) and the holoptic form (Fig. 11) (in the proportion 44 : 5, n = 49).

Dichoptic form. Body length (alcohol preserved specimens) 1.3–1.9 mm (n = 18), wing length 1.1–1.3 mm (n = 8), wing width 0.5–0.6 mm (n = 6).

Coloration and form of head as in female except head small relative to that of female and holoptic male (Figs 9–11). Frons at narrowest point about one-eighth width of head at that point compared to about one-sixth in the female. Antennae of dichoptic males longer in proportion to depth of head (ommatidial area) (1.25 : 1) than in females (0.9 : 1), and the antennae of these males are thinner.

Coloration and setation of thorax and appendages as in female except claws of male type (Fig. 147).

Coloration of abdomen as in *S. exiguum* male except central area of tergite V silver. Basal fringe short as in female *S. gonzalezi*. Genitalia as in male *S. exiguum* except ventral plate more rectangular than triangular and basal arms more

developed (Figs 77, 78) and median sclerite narrower at base (Fig. 91).

Holoptic form. Body length (alcohol preserved specimen) 2 mm (n = 1). Coloration and morphology as in male *S. exiguum* except in the single specimen dissected ventral plate shows a small protuberance adjacent to basal arms (Fig. 79).

Pupa. Female and dichoptic male pupae: cocoon length dorsally 1.5–2.4 mm, ventrally 1.9–2.7 mm; pupa length 1.4–2.2 mm; gill length 1.1–1.8 mm (n = 41). Holoptic male pupae: cocoon length dorsally 1.6–2.2 mm, ventrally 2.2–2.6 mm; pupa length 1.6–2.2 mm; gill length 1.0–1.4 mm (n = 5)

Cocoon as in *S. exiguum* (Fig. 104). Pupal morphology of female and both male forms as in *S. exiguum* except for gill. Gill light brown with six forwardly directed slender filaments arranged irregularly in a vertical plane (Fig. 111); main trunk giving rise to three primary branches each of which bears a single bifurcation. Dorsal branch with basal bifurcation at about one-tenth length of total gill, ventral bifurcation the most distal occurring at about a fourth the length of the gill and median bifurcation between those of the dorsal and ventral primary branches, although it may occasionally arise at the same distance from the gill base as that on the ventral branch.

Mature larva. Body length 2.8–4.6 mm (n = 43). Width of head capsule 0.3–0.4 mm (n = 43). Body colour and form as *S. exiguum*. *S. gonzalezi* may be distinguished from *S. exiguum* by the negative head pattern (Fig. 124) although the concolorous state typical of *S. exiguum* sometimes occurs.

MATERIAL EXAMINED

Belize: 23 ♀, nr Caya, Augustine, 27.vii.1981 (*D. J. Lewis*) (BMNH).

Ecuador: numerous reared adults, pupae and larvae from the following localities in the Santiago onchocerciasis focus in Esmeraldas Province: R. Cayapa, San Miguel de Cayapas, 17–19.vi.1981 (*A. J. Shelley & M. Arzube*) (BMNH, INHMT); R. San Miguel, San Miguel de Cayapas, 17.vi.1981 (*A. J. Shelley & M. Arzube*) (BMNH, INHMT); R. Sapallo Grande, Tumbaviro, 26.v. and 18.vi.1981 (*A. J. Shelley & M. Arzube*) (BMNH, INHMT); R. Grande (Cayapa), Viruela and Calle Mansa, 24–27.v.1981 (*A. J. Shelley & M. Arzube*) (BMNH, INHMT); numerous reared adults, pupae and larvae from the Canandé peripheral onchocerciasis focus in Esmeraldas Province, R. Canandé, Naranjal, 25.ix.1983 and 21–24.vi.1985 (*A. J. Shelley & M. Arzube*) (BMNH, INHMT).

Guatemala: 3 ♀, Departamento Chimaltenango, Finca Sibaja, 6.xi.1974 (*R. Garms*) (BMNH).

Mexico: 1 ♀, Tamazunchale, SLP, ix.1944 (*M. Macias*) (BMNH).

TAXONOMIC DISCUSSION. *Simulium gonzalezi* is most closely related to *S. exiguum* and *S. paraguayense* Schrottky as detailed in the taxonomic discussion on *S. exiguum*.

In the Santiago onchocerciasis focus, as well as in the Canandé peripheral onchocerciasis focus, the dichoptic form of the male head is the more prevalent. A similar situation has already been reported for this species from a locality in the Oaxaca onchocerciasis focus in Mexico, where Dampf (1944) recorded this species (as *exiguum*). In the Yepocapa onchocerciasis focus in Guatemala, however, the holoptic male condition is more prevalent (Dalmat, 1955; Takaoka, 1983).

DISTRIBUTION. In Ecuador *Simulium gonzalezi* has only been recorded from the main Santiago and peripheral Canandé onchocerciasis foci. It is also known from many localities in southern Mexico (Vargas & Diaz Najera, 1957), Guatemala (Dalmat, 1955) and Belize (BMNH collection). Lewis (1963) records an eight-filamented pupa of *S. gonzalezi* from Antigua but there is insufficient evidence presented for this species determination.

BIOLOGY. In Ecuador *S. gonzalezi* appears to be totally zoophilic although its main host has not yet been determined; using a horse as bait 401 *S. exiguum* and one *S. gonzalezi* were collected in two hours at the Canandé peripheral onchocerciasis focus (Shelley & Arzube, unpublished data). Though biting a variety of animals in Central America it will often attack man in large numbers there. Dalmat (1955) records *S. gonzalezi* (as *S. exiguum*) as being mainly zoophilic with a preference for large domestic stock (bovines and equines) but in the lower altitudes (under 800 m) of the Yepocapa onchocerciasis focus it is the dominant man-biter (Gibson & Dalmat, 1952, as *S. exiguum*). In Mexico *S. gonzalezi* probably shows similar biting habits (Shelley, 1988) and specimens (now in BMNH) have been obtained biting both man and mules in Belize.

Simulium gonzalezi is found in similar breeding grounds to those of *S. exiguum* in Ecuador but, as in Guatemala (Dalmat, 1955), shows a preference for larger rivers over 10 m wide.

Although not a vector of onchocerciasis in Ecuador because of its zoophilic habit, *S. gonzalezi* is nevertheless an important species because of its sympatry with and similarity to the primary vector *S. exiguum*. In Mexico and Guatemala it is suspected as a secondary vector of onchocerciasis because of its man-biting habit in the onchocerciasis foci and the finding of filarial larvae in wild females (Shelley, 1988).

Simulium (Psilopelmia) bipunctatum Malloch

(Figs 26, 32, 38, 44, 50, 57, 64, 70, 80, 81, 92, 98, 105, 112, 118, 125, 133, 140, 148)

Simulium bipunctatum Malloch, 1912: 650. Holotype ♀, PERU: Rio Charape, 13.ix.1911 (*C. H. T. Townsend*) (USNM, Cat. No. 15305) [examined]. [Synonymised with *S. dinellii* Joan by Knab, 1913: 155; revalidated by Coscaron, 1985: 320.]

Simulium antillarum Jennings, 1915: 200. Lectotype ♂, VIRGIN ISLANDS: St Croix Island, 1.5 miles west of West End, Frederiksted, 24.xi.1913 (*A. H. Jennings*) (USNM Cat. No. 19997) by designation of Stone (1969: 313) [examined]. **Syn. n.**

Simulium wolcotti Fox, 1953: 138. Holotype ♂, PUERTO RICO: Henry Barracks, near Cayey, 1950 (*I. Fox*) (STMPR). [Synonymised with *S. antillarum* Jennings by Stone, 1969: 313.] **Syn. n.**

Simulium pseudoantillarum Ramirez Perez & Vulcano, 1973: 379. Syntypes 1 ♀, 1 ♂, VENEZUELA: Monagas State, San Antonio de Maturin, (no collection date) (*Ramirez Perez & Vulcano*) (DDSV). **Syn. n.**

DESCRIPTION. *Female*. General body colour orange. Body length (alcohol preserved specimens) 2.1–3.5 mm (n = 30), wing length 1.7–2.7 mm (n = 30), wing width 0.9–1.2 mm (n = 30).

Head dichoptic with red eyes; nudiocular area poorly developed (Fig. 26). Frons, clypeus and occiput black with silver pruinosity. Mouthparts black. Antennae orange with distal third to half dark brown. Cibarium with central trough unarmed and sclerotised and a group of about 20 small teeth forming a protuberance on each side of trough that do not reach the sclerotised cornuae (Fig. 32).

Scutum dirty yellow with three prominent longitudinal orange bands that coalesce posteriorly; median band commences on anterior border of scutum and occupies three-quarters of its length; the pair of lateral bands commence in the second quarter of the scutum and continue to posterior margin. Scutum with a pair of submedian silver comma-shaped marks commencing at interface between yellow anterior margin and orange area and running half length of scutum. Lateral margins of scutum yellow and faintly pruinose (not obvious as in *S. lewisi*). Paranotal folds orange-brown in fresh specimens, often becoming dark brown in preserved material. Scutum with numerous adpressed black setae lying singly. Pleural region varying from light orange to mid brown with faint silver pruinosity. Scutellum and postnotum orange; posterior margin of scutellum with erect black bristles (Fig. 140).

Subcostal wing vein with line of setae almost to distal extremity, basal section of *R* with two or three irregular rows of setae. Costal base tuft dark brown (Fig. 38).

Fore leg coxae, trochanters and femora of all legs orange to light brown; coxae of mid and hind legs light brown on anterior half, dark brown on posterior half; tibiae and tarsi of all legs dark brown. Mid and hind leg femora and tibiae with darker distal articulations. Claws curved with large basal tooth (Fig. 44). Proportions of legs as in Fig. 140. Halteres yellow with light brown stems.

Abdominal tergites from orange to brown depending on age of specimen and whether it has blood fed; older blood fed specimens tend to become dark brown. Tergites I–IV usually mottled light brown and yellow but can be yellowish orange, particularly in reared material, occasionally mid brown; tergite V usually matt grey but sometimes matt black; tergites VI–IX dull mottled mid and light brown but sometimes completely shiny brown or black (Fig. 140). Tergal plates (Fig. 4) well-developed and generally light brown, sometimes dark brown. Sternites and genitalia orange to light brown becoming dark brown in preserved specimens. Eighth sternite usually lightly sclerotised with 20–24 setae on each side; gonopophyses small, membranous with minute hairs on inner margin (Fig. 50). Cerci hemispherical; paraprocts with pronounced ventral extension (Fig. 57). Genital fork slender with well-developed triangular anterior processes (Fig. 64). Spermatheca similar to that of *S. exiguum* (Fig. 5), oval, sclerotised, with surface covered in regular rounded depressions and spicules of inner surface randomly arranged; area of insertion of spermathecal duct membranous and a third as wide as maximum width of spermatheca.

Male. General body colour orange. Body length (alcohol preserved specimens) 2.0–3.4 mm (n = 15); wing length 1.8–2.4 mm (n = 15); wing width 0.9–1.0 mm (n = 15).

Head holoptic with red eyes. Clypeus black with silver pruinosity. Rest of head coloration as in female.

Coloration and hairing of scutum, pleural region, scutellum and postnotum as in female (Fig. 148).

Subcostal wing vein bare or with variable number of setae (1–7) in central portion, basal section of *R* with a single row of setae.

Leg (Fig. 148) and haltere coloration as in female.

Abdominal tergites I–IV mottled orange and light brown; tergites V–IX and genitalia light brown; basal tuft of light orange hairs. Silver ornamentation as follows: tergites VI and VII with a pair of submedian silver pruinose patches, anterior margin of tergite II and all of tergite IX faintly pruinose (Fig. 148). Sternites I–IV light orange, V–IX dark brown; sternal plates well-developed only on segments V–VIII (cf. Fig. 6). Genitalia orange to light brown. Gonocoxite longer than wide; gonostyle small, half the length of the gonocoxite, curved and conical with apical spine (Fig. 70). Ventral plate (Figs 80, 81) with reduced and lightly sclerotised basal arms and a small keel; hairs long and covering most of ventral plate. Median sclerite (Fig. 92) slightly longer than wide with deep apical incision occupying about half the length of the sclerite. Paramere as in Fig. 98 with few, well-developed, mainly apical spines and several smaller spines.

Pupa. Length of cocoon dorsally 2.1–3.2 mm, ventrally 2.8–4.2 mm; length of pupa 2.0–3.3 mm; length of gill 2.5–3.2 mm (n = 38).

Cocoon slipper-shaped, dark brown; rim of aperture dark brown, reinforced and usually without median protuberance (Fig. 105). Cocoon composed of thick threads producing an open weave, particularly laterally at point of adhesion to substrate. Gill light brown with eight forwardly directed slender filaments arranged irregularly in a vertical plane (Fig. 112): main trunk giving rise to three primary branches, ventral with two filaments and median and dorsal each with three filaments; filaments arise basally on all primary branches; filaments slender with crenated margins and rounded distally, their surfaces covered with fine spicules as in *S. exiguum* (Fig. 12). Head similar to that of *S. exiguum* (Fig. 13) with 2 + 2 frontal and 1 + 1 facial bifid or trifid well-developed trichomes; surface of head with sparsely distributed platelets. Thorax similar to *S. exiguum* (Fig. 17) with 5 + 5 trichomes on anterior border, each with two to five trichomes, 1 + 1 postero-dorsal and 1 + 1 ventral unbranched trichomes. Surface of thorax covered with platelets mainly concentrated around the dorsal region. Abdominal tergites II–IV with 4 + 4 simple hooks, more weakly developed on segment II, VI–IX with spine combs on anterior margins, tergite IX with 1 +1 strong unbranched spines (Fig. 19); sternite IV in female with 2 + 2 simple hooks, in male reduced to fine setae, sternites V–VII with 2 + 2 simple to bifid hooks; 1 + 1 patches of spine combs on postero-lateral borders of sternites IV–VIII (Fig. 20).

Mature larva. Body length 3.8–5.8 mm (n = 46). Width of head capsule 0.4–0.6 mm (n = 46). Body colour grey in both alcohol and Carnoy's preserved specimens. Body form as in Fig. 118.

Head yellow with brown markings and several scattered minute setae on all surfaces. Head pattern negative as in Fig. 125, consisting of a central clear area and 1 + 1 antero-lateral and 1 + 1 postero-lateral clear areas of head spots within a dark background confined to the posterior half of the cephalic apotome. More rarely the head pattern may be positive (Fig. 126) and this form has also been recorded outside the focus. Postgenal cleft large, longer than wide, with pointed anterior margin; postgenal bridge short, one-third as long as hypostomium (Fig. 133). Hypostomium of type seen in *S. exiguum* (Fig. 21). Antennae long, brown and with segment ratios 12 : 14 : 17. Mandible as in *S. exiguum* (Fig. 23) with one to three mandibular serrations, of which anterior is usually larger. Maxillary palp short, about twice as long as breadth at base. Cephalic fan with 34–42 rays.

Thorax whitish grey dorsally, darker grey ventrally, either diffuse or concentrated into one to three central patches posterior to the proleg. Cuticle with minute scattered hairs on dorsal and lateral surfaces. Proleg plates lightly sclerotised with 10–12 processes. Pupal respiratory histoblast dark brown and claviform.

Abdomen whitish with four grey bands encircling the body on the four (narrow) anterior segments, bands more obvious dorsally; posterior (wide) segments of abdomen brownish grey dorsally and whitish laterally and ventrally. Ventral papillae small (Fig. 118). Cuticle with minute scattered hairs on dorsal and lateral surfaces as in thorax but in greater density on postero-dorsal region. Anal sclerite well sclerotised with posterior arms extending to twelfth row of posterior circlet hooks. Posterior circlet with about 62–71 rows of 1 to 12 hooks. Anal gill tri-lobed as in *S. exiguum* (Fig. 24), each lobe with 4–7 short, secondary lobules.

Material examined

Holotype ♀ of *S. bipunctatum*, **Peru**: Rio Charape, 13.ix.1911 (*C. H. T. Townsend*) (USNM); paratype ♀ (collection data as for holotype) (BMNH). Lectotype ♂, paralectotype ♀, various topotypic pupae of *antillarum*, **St Croix Island**: Frederiksted, 24.xi.1913 (*A. H. Jennings*) (USNM).

Brazil: 3 ♀, Roraima, MEVA Mission post, Auaris, 7.vii.1976 (*A. J. Shelley*) (BMNH); 10 ♀, Amazonas, R. Vaupes, Igarapé Tiquié, 15. xii.1977 (*C. Vicente*) (BMNH, IOC).

Colombia: 3 ♀, Norte de Santander,

Arboledas, Siravita, La Esperanza, 25.xi.1984 (*B. Alexander*) (BMNH).

Dominica: 6 ♀, Roseau, 7.vii.1974 (*L. J. Charles*) (BMNH).

Ecuador: numerous reared adults, pupae and larvae from following localities in the Santiago onchocerciasis focus, Esmeraldas Province, R. Cayapa, 18–21.vi.1981 (*A. J. Shelley & M. Arzube*) (BMNH, INMHT); R. Cayapa, stream 4 km below San Miguel de Cayapas, 17.vi.1981 (*A. J. Shelley & M. Arzube*) (BMNH, INHMT); R. Cayapa, above Sapallo Grande Mission, 28.v.1981 (*A. J. Shelley & M. Arzube*) (BMNH, INMHT); R. San Miguel, small stream 100 m above San Miguel de Cayapas, 17.vi.1981 (*A. J. Shelley & M. Arzube*) (BMNH, INHMT); R. San Miguel de Cayapas, Estero Hacha, 26.v.1981 (*A. J. Shelley & M. Arzube*) (BNMH, INMHT).

Jamaica: 8 ♀, Loaf Water, 6.iii.1958 (*D. J. Lewis*) (BMNH); 2 ♀ 2 ♂ (ex pupae), Pindars River, near Kellits, 17.vii.1970 (*Clarendon*) (BMNH).

Montserrat: 4 ♀, Montserrat Woodlands, 20.ix.1938 (*F. A. S.*) (BMNH).

Venezuela: 8 ♀, 10 pupae, Monagas State, localities near San Antonio de Maturin, v.1961 (*D. J. Lewis*) (BMNH) [labelled by Lewis as sp. D and regarded by Ramirez Perez as *S. pseudoantillarum*].

The following specimens of two species closely related to *S. bipunctatum* were examined and are referred to in the following taxonomic discussion.

Simulium dinellii Joan

Argentina: 27 ♀, Jujuy (collection date unkown) (*W. C. Paterson*) (BMNH).

Peru: 19 ♀, Apurimac, Cuzco-Abancay road, Apurimac crossing at Cuya, 7.viii.1971 (*C. & M. Vardy*) (BMNH).

Simulium ochraceum Walker

Guatemala: 3 ♀, Department Chimaltenango, Finca Sta. Anita, 8.iii.1974 (*R. Garms*) (BMNH); 1 ♀ , 2 ♂, Department Chimaltenango, Acantenango, 2.x.1948, 8.vi.1949 (*H. Dalmat*) (BMNH).

Mexico: 3 ♀, Chalchihuitan, 4.xii.1940 (*J. Parra*) (BMNH); 10 ♀, Chiapas State, Huixtla, x.1958 (*R. W. Crosskey*) (BMNH).

Panama: 1 ♀, Chiriqui Province, Los Planes de Hornito, 12.ix.1978 (*J. Petersen*) (BMNH).

Taxonomic discussion. *Simulium bipunctatum* was first described by Malloch (1912) from females collected in Peru (and presumably biting man) in a survey for the possible transmitters of pellagra. This name was then synonymised by Knab (1913) with *S. dinellii* Joan from Argentina after he had compared the holotype of *S. bipunctatum* with the original description of the former. He neglected to observe that Malloch named *S. bipunctatum* after the two submedian, white comma-shaped marks on the female scutum whilst Joan (1912) had clearly noted the absence of scutal patterns in *S. dinellii*. Wygodzinsky (1950) questioned Knab's synonymy of *bipunctatum* with *dinellii* in a paper redescribing the latter species. Recently, Coscaron (1985) recalled *S. bipunctatum* from synonymy after examining the holotype in the USNM and topotypic material. His study confirmed the distinctness in scutal patterns of the two species and also revealed differences in the morphology of the paraproct. We support this revalidation after comparing a paratype of *S. bipunctatum* donated to the BMNH by the USNM, with specimens of *S. dinellii* in the BMNH collection that correspond to Joan's original description and the more detailed description of Wygodzinsky (1950). We base our synonymy of *S. antillarum* Jennings with *S. bipunctatum* on a comparison of the male lectotype and a female paralectotype (USNM) of the former with the holotype of the latter. Examination of large numbers of specimens of '*antillarum*' from the Caribbean Islands and Ecuador showed variation in the sclerotisation and dentition of the female cibarium, characters which Coscaron (1985) uses to separate it from *bipunctatum*. The detailed descriptions and comments of Coscaron, (1985), Diaz Najera (1961), Floch & Abonnenc (1946), Jennings (1915), Rubtsov & Garcia Avila (1972), Smart (1940) and Vargas & Diaz Najera (1951) for *S. antillarum* and the original description of *S. bipunctatum* by Malloch (1912) were consulted.

We accept Stone's (1969) synonymy of *S. wolcotti* with *S. antillarum* because of his comparison of topotypes of the former with the original syntype series of *S. antillarum*, which did not confirm Diaz Najera's observations (1961) supporting the validity of *S. wolcotti* based on coloration. Following our synonymy of *S. antillarum* with *S. bipunctatum*, *S. wolcotti* becomes a new junior synonym of *S. bipunctatum*. Coscaron (1985) omits *S. wolcotti* from his revision of the subgenus *Ectemnaspis*.

The synonymy of *S. pseudoantillarum* Ramirez Perez & Vulcano is based on the following observations. *Simulium pseudoantillarum* was described by Ramirez Perez & Vulcano (1973) from collections that they had made in the region of the onchocerciasis foci of northern Venezuela. The specimens are listed as paratypes but as no holotype was designated they have syntype status. The authors cite the BMNH as a depository but no

specimens have yet been received and all type material is presumed to be in the 'Seccion de Oncocercosis, Villa de Cura, Venezuela'. This species corresponds with '*Simulium* sp. D' of Lewis (1963) who had previously collected in the same area and made a preliminary description. Ramirez Perez & Vulcano (1973) state that *S. pseudoantillarum* is closely related to *S. antillarum* but can be distinguished from it by differences in size, the form of the pedisulcus and calcipala in the female and in the more distal bifurcation of pupal gill filaments. Their conclusions are stated to have been made after a comparison of *S. antillarum* types in the BMNH and of descriptions of this species by Jennings (1915), Diaz Najera (1961) and Floch & Abonnenc (1946). We have no record of the *S. antillarum* types having been on loan to the BMNH from their depository the USNM. We have examined topotypic material collected by Lewis in Venezuela in 1961 and identified as *Simulium* sp. D (Lewis, 1963) and found that the figure of a pupal gill with the relatively distal bifurcations of filaments arising on the median primary gill branch is atypical for the sample, the majority of the specimens having a gill form as in *S. antillarum* (Fig. 112). Ramirez Perez & Vulcano (1973: 380, fig. 2) copied Lewis figure of the gill (Lewis, 1963: 57, fig. 3H) but mistakenly state that it is a more detailed figure of their figure 1, which is obviously of another specimen. In later works Ramirez Perez (1983) and Ramirez Perez *et al.* (1982) figure the gill of *S. pseudoantillarum* with basal branching typical of *S. antillarum*. Taking into account the natural variation in adult size, the lack of detectable difference in the form of calcipala and pedisulcus, and the natural variation in gill configuration, we consider *S. pseudoantillarum* to be conspecific with *S. antillarum* and hence synonymous with *S. bipunctatum*. Coscaron (1985) suggests that *S. pseudoantillarum* may fall within the natural variation of *S. antillarum*.

We retain *Simulium bipunctatum* in the subgenus *Psilopelmia* and do not follow Coscaron's inclusion (1985) of this species in *Ectemnaspis*. It is morphologically most closely related to *S. ochraceum* which differs in its dark postnotum and legs. Simuliid species with orange coloration preserve badly, both as pinned and alcohol specimens, and female coloration can be influenced by whether the specimen is blood fed or not. Variation in coloration of the key characters of the thorax and abdomen in both species is apparent in the specimens in the BMNH collection. The distinctness of the two species needs to be more thoroughly investigated to take into account intraspecific variation by using both morphological and cytological methods on long series of specimens from different localities.

Distribution. Distribution of *S. bipunctatum* is based upon the BMNH collections and Stone (1969, as *antillarum*). In Ecuador *S. bipunctatum* has only been reported in Esmeraldas Province. Its distribution in South America includes northern Brazil, Colombia, Peru and northern and southern Venezuela. In Central America it has been reported from the following Caribbean Islands: Cuba, Dominica, Guadeloupe, Jamaica, Montserrat, Puerto Rico, St Croix, and Trinidad as well as from mainland Mexico.

Biology. *Simulium bipunctatum* will bite man to varying degrees in different localities. In the onchocerciasis focus of Ecuador (Shelley & Arzube, 1985) and in the majority of the Caribbean Islands and Mexico (Stone, 1969; Rubtsov & Garcia Avila, 1972) it is mainly zoophilic, only rarely coming to bite man. It is, however, markedly anthropophilic in the Upper Amazon region of Brazil along the R. Vaupes but only occasionally bites man (possibly due to small fly populations rather than zoophilic tendencies) farther north in the Amazonia onchocerciasis focus of Brazil and Venezuela (Ramirez Perez *et al.*, 1982; Shelley, 1988; Shelley & Luna Dias, unpublished data). In parts of Guadeloupe it can also be a biting nuisance (Floch & Abonnenc, 1946).

Simulium bipunctatum breeds in shaded, slow-flowing streams in lowland forest of Ecuador (Shelley & Arzube, 1985) and in fast flowing small streams in St Croix and Jamaica (Jennings, 1915). In Cuba (Rubtsov & Garcia Avila, 1972) it occurs in small streams up to an altitude of 1200 m throughout the year. In the Amazonia onchocerciasis focus of Brazil and Venezuela it occurs in slow flowing streams (1 m wide, Ramirez Perez *et al.*, 1982) and larger rivers (up to 20 m wide, Shelley & Luna Dias, unpublished data) in highland forested areas.

Simulium (Psilopelmia) lewisi Ramirez Perez

(Figs 27, 33, 39, 45, 51, 58, 65, 71, 82, 83, 93, 99, 106, 113, 119, 127, 134, 141, 149)

Simulium lewisi Ramirez Perez, 1971: 349. Holotype ♀, Venezuela: Miranda State, Panaquire (No collection date; collector presumably *J. Ramirez Perez*) (DERM).

Simulium iguazuense Coscaron 1976a: 147. Holotype [sex unspecified], Argentina: Parque Nacional Iguazu, route 101, in unnamed stream or Arroyo Nandu [not specified], 17.x.1974 (*S. Coscaron*) (MLP). [Synonymised with *S. lewisi* by Coscaron, 1985: 304.]

DESCRIPTION. *Female*. General body colour orange and black. Body length (alcohol preserved specimens) 1.6–2.3 mm (n = 11); wing length 1.8–2.1 mm (n = 10), wing width 0.8–1.0 mm (n = 10).

Head dichoptic with dark red eyes; nudiocular area poorly developed (Fig. 27). Frons, clypeus and occiput black with silver pruinosity. Mouthparts mid brown, maxillary palps dark brown. Antennae dark brown with scape and pedicel and first flagellomere orange. Cibarium with five irregular rows of blunt tubercles in area of central trough and a group of about 20–30 minute teeth between this and each cornua; anterior margin of cibarium sclerotised (Fig. 33).

Scutum orange, humeri yellow to light orange, lateral scutal margins yellowish orange with brilliant white pruinosity. Paranotal folds dark brown with silver pruinosity. Scutum with numerous adpressed dark brown hairs lying singly. Pleural region mainly dark brown with faint silver pruinosity although in some specimens orange to light brown areas may occur in the area adjacent to the paranotal folds. Scutellum orange with erect brown hairs on posterior margin. Postnotum dark brown with faint silver pruinosity (Fig. 141).

Subcostal wing vein usually with one to six setae in the median third of the vein, in some cases without setae; basal section of *R* with single row of setae to base of vein (Fig. 39). Costal base tuft of dark brown setae.

Legs black except basal two-thirds of mid and hind basitarsi which are white (Fig. 141). Claws curved, each with a small tooth as in Fig. 45. Proportions of legs as in Fig. 141. Halteres yellow with light brown stems.

Abdominal tergites I–III bright yellow, sometimes orange, tergite IV velvet-black, tergites VI–IX shiny black or mottled brown and black (Fig. 141). Occasionally specimens occur in which tergites I–IV are yellow, in which case tergite V is velvet-black. Tergal plates (Fig. 4) well developed on segments IV–IX. Sternites I–III yellowish brown, rest mid brown, genitalia dark brown. Eighth sternite well sclerotised with about 15–18 setae on each side; gonopophyses small, membranous with minute hairs (Fig. 51). Cerci hemispherical; paraprocts with pronounced ventral extension (Fig. 58). Genital fork slender with sclerotised, triangular anteriorly-directed processes (Fig. 65). Spermatheca similar to that of *S. exiguum* (Fig. 5), oval, sclerotised, with no external sculpturing and randomly distributed spicules on internal surface. Area of insertion of spermathecal duct membranous, one-third as wide as maximum width of spermatheca.

Male. General body colour orange and black. Body length (alcohol preserved specimens) 1.9–2.8 mm (n = 15), wing length 1.7–2.1 mm (n = 15), wing width 0.8–1.0 mm (n = 15).

Head holoptic with dark red eyes. Coloration of rest of head as in female.

Coloration and hairing of thorax and its appendages as in female (Fig. 149) except subcostal vein of wing devoid of setae. Morphology of legs as in Fig. 149.

Abdominal tergites I–III yellow, rest of tergites and genitalia velvet-black; basal fringe of long black hairs. Silver ornamentation on tergites as follows: tergite II faintly silver pruinose and tergites VI, VII and IX with obvious silver patches laterally (Fig. 149). Sternites I–III orange, IV–IX dark brown with well-developed sternal plates (Fig. 6) on segments IV–VIII. Gonocoxite longer than wide, gonostyle with distal spine longer than wide and about half length of gonostyle (Fig. 71). Ventral plate membranous with lightly sclerotised, reduced basal arms, a small keel and hairs covering most of its surface (Figs 82, 83). Median sclerite pyriform with small apical incision (Fig. 93). Paramere as in Fig. 99 with few distal spines of varying sizes.

Pupa. Cocoon length dorsally 1.9–2.7 mm, ventrally 2.3–3.0 mm; pupa length 1.6–2.5 mm; gill length 2.2–2.7 mm (n = 32).

Cocoon slipper-shaped, white under natural conditions and light brown in alcohol; rim of aperture thickened and without median protuberance, median thickened dorsal ridge connecting with rim of aperture (Fig. 106). Cocoon very thick, composed of amorphous elastic substance containing fibres which are only apparent under higher magnification. Gill light brown with eight forwardly directed slender filaments arranged in a vertical plane (Fig. 113); main trunk giving rise to three primary branches, ventral with two filaments and median and dorsal each with three filaments; ventral branch bifurcation at limit of basal third of total gill length, first division of median and dorsal branches arise in the same region but individual specimens vary in the exact position – some showing divisions at the same distance from the gill base in all three branches while in others these divisions occur at different points on each branch, the most dorsal of the two filaments arising from this division in the median and dorsal primary branches again bifurcate, usually at the same level on each branch, at the mid point of the gill; filaments slender with crenate edges, rounded distally, their surfaces covered in spicules as in *S. exiguum* (Fig. 12). Head as in Figs 13, 14 of *S. exiguum* with 2 + 2 frontal trichomes usually with 4–6 branches but sometimes up to

eight and 1 + 1 facial trichomes with 2–4 branches, trichomes well-developed; surface of head with few platelets mainly concentrated around the facial trichomes. Thorax as in *S. exiguum* (Fig. 17) with 5 + 5 well-developed trichomes with 6–8 branches on anterior margin of thorax. Anterior half of surface of thorax with scattered platelets. Abdominal tergite II with 4 + 4 simple hairs, III–IV with 4 + 4 simple hooks, VI–IX with spine combs on anterior margins, tergite IX with 1 + 1 unbranched spines (Fig. 19); sternite IV in both sexes with 1 + 1 inner simple or bifid hooks and 1 + 1 outer fine setae (developed as hooks in *bipunctatum*), V–VII with 2 + 2 hooks with 1 to 3 branches; 1 + 1 patches of spine combs on postero-lateral borders of sternites IV–VIII (Fig. 20).

Mature larva. Body length 3.7–4.9 mm (n = 23). Width of head capsule 0.4–0.5 mm (n = 23). Body colour white with either greyish purple or green markings. These colour variations are not sex linked (W. S. Procunier, pers. comm.). In Carnoy's fixative markings are bright purple or green and more distinct. Body form as in Fig. 119.

Head yellow with scattered minute setae on all surfaces. Head spots generally indistinct being the same colour as the rest of the head capsule, but in some specimens a negative pattern occurs (Fig. 127). Postgenal cleft large, longer than wide, with rounded anterior margin; postgenal bridge short, about one-tenth as long as hypostomium (Fig. 134). Membrane within postgenal cleft containing green or grey chromatocytes that obscure the outline of the cleft. Hypostomium of type figured for *S. exiguum* (Fig. 21). Antennae long, light brown, with segment ratios 14 : 13 : 12. Mandible as in *S. exiguum* (Fig. 23) except second comb tooth shorter than the first or third. Maxillary palp short, about twice as long as width at base. Cephalic fan with 30–34 rays.

Thorax whitish grey with few scattered dark greyish purple spots dorsally and two central greyish purple patches ventrally posterior to the proleg. In some specimens green replaces the grey coloration. Cuticle with scattered small hairs on ventral and lateral surfaces but densely distributed on the dorsum. Proleg plate lightly sclerotised with about twelve processes. Pupal respiratory histoblasts dark brown and ovoid. Abdomen whitish grey with a prominent dark greyish purple band at the anterior end and at the posterior end of the narrow abdominal segments, posterior (wide segments) of abdomen with four dorsal dark greyish purple bands that often coalesce and scattered patches of grey pigment laterally and ventrally. Pigment in some specimens is green. Ventral papillae absent or very reduced and indistinct. Cuticle with densely distributed minute hairs on dorsum, more scattered laterally and absent ventrally. Anal sclerite well sclerotised with posterior arms extending to the twelfth row of posterior circlet hooks. Posterior circlet with 56–60 rows of 4–14 hooks. Anal gill trilobed as in *S. exiguum* (Fig. 24), median lobe with 6–7 secondary lobules, lateral lobes with 8–11 secondary lobules.

MATERIAL EXAMINED

Paratypes of *S. lewisi*, **Venezuela**: 1 ♀ (ex pupa), Miranda State, Panaquire (no collection date) (*J. Ramirez*) (BMNH); 1 ♀ (ex pupa), Miranda State, Acevedo District, Panaquire, Rio Yaguapo, (no collection date) (*J. Ramirez*) (BMNH); 1 ♀ (ex pupa), Carabobo State, Virigima (no collection date) (*J. Ramirez*) (BMNH); 1 ♂ (ex pupa), Barinas State, Rio Socopo (no collection date) (*J. Ramirez*) (BMNH).

Ecuador: numerous reared adults, pupae and larvae from the following localities in the Santiago onchocerciasis focus of Esmeraldas Province: San Miguel de Cayapas, Rio San Miguel, 25, 26.v. & 17.vi.1981 (*A. J. Shelley & M. Arzube*) (BMNH, INMHT); Tumbaviro, R. Sapallo Grande, 26.v. & 18–25.vi.1981 (*A. J. Shelley & M. Arzube*) (BMNH, INMHT); San Miguel de Cayapas and Calle Mansa, Rio Cayapa, 27.v. & 17.vi.1981 (*A. J. Shelley & M. Arzube*) (BMNH); numerous reared adults, pupae and larvae from the Canandé peripheral onchocerciasis focus in Esmeraldas Province, Naranjal, Rio Aguas Negras, Naranjal and Canandé, 23–25.vi.1983 (*A. J. Shelley & M. Arzube*) (BMNH, INMHT); 1 ♀ (ex pupa), Esmeraldas Province, Tululbi (Ricaurte), Rio Bogota, 13.ix.1983 (*A. J. Shelley & M. Arzube*) (BMNH); 3 ♀ (ex pupae), Tululbi (Ricaurte), Riachuelo Nadadeiro, 14.ix.1983 (*A. J. Shelley & M. Arzube*) (BMNH, INMHT); 2 ♂ (ex pupae), Santo Domingo-Esmeraldas road, R. Caoni, 24.ix.1983 (*A. J. Shelley & M. Arzube*) (BMNH, INHMT); 3 ♀ 2 ♂ (ex pupae), Pichincha Province, Quito-Santo Domingo road, Rio Tanti, 28.ix.1983 (*A. J. Shelley & M. Arzube*) (BMNH); pupae, Napo Province, near Lago Agrio, 14.xii.1982 (*A. J. Shelley & M. Arzube*) (BMNH, INMHT).

Venezuela: 1 ♀ (ex pupa), Miranda State, Acevedo District, El Clavo, Rio Sapo (no collection date) (*J. Ramirez*) (BMNH); 2 ♀ 1 ♂, [Aragua State], Altagracia, Quebrada Caranacare, 28.vi.1961 (*D. J. Lewis*) (BMNH); 1 ♀ [Aragua State], Tucuyito, Rio Aguacatal, 14.vi.1961 (*D. J. Lewis*) (BMNH).

The following closely related species were also examined and are referred to in the taxonomic discussion.

S. alirioi Ramirez-Perez & Vulcano

Venezuela: 2 ♂, Monagas State, San Antonio de Maturin, Rio Negro, 23.v.1961 (*D. J. Lewis*) (BMNH); 4 pupae, Paratebueno, v.1961 (*D. J. Lewis*) (BMNH).

S. gabaldoni Ramirez-Perez

Paratypes 2 ♀ (ex pupae), **Venezuela**: Monagas State, San Francisco (no collection date) (*J. Ramirez*) (BMNH).

Venezuela: 1 ♂ (ex pupa), Monagas State, San Antonio (no collection date) (*J. Ramirez*) (BMNH).

S. lutzianum Pinto

Ecuador: 1 ♀ (ex pupa), Imbabura Province, Salinas-Lita road, 54 km from Ibarra, Rio San Pedro, 11.ix.1983 (*A. J. Shelley & M. Arzube*) (BMNH); 10 ♀ 4 ♂ (ex pupae), Pichincha Province, Quito-Santo Domingo road, Rio Tanti and Riachuelo Lelia, 28 & 29.ix.1983 (*A. J. Shelley & M. Arzube*) (BMNH); 1 ♂ (ex pupa), Manabi Province, Chone-Santo Domingo road, Rio Maceto, 10.xii.1984 (*M. Arzube*) (BMNH); 2 ♀ 2 ♂ (ex pupa), Pastaza Province, Tena-Puyo road, Rio Puyo, Rio Mira Valle and Riachuelo Huamayacu, 8 & 9.vi.1985 (*A. J. Shelley & M. Arzube*) (BMNH); 3 ♀ (ex pupae), Cotopaxi Province, Quevedo-La Mana-La Pilalo road, Rio San Pablo, 8.vi.1984 (*A. J. Shelley & M. Arzube*) (BMNH).

Venezuela: 1 ♀ 1 ♂ (ex pupa), Carabobo State, Montalban (no collection date) (*J. Ramirez*) (BMNH); 2 ♀ 1 ♂ (ex pupae), Aragua State, Rancho Grande (no collection date) (*J. Ramirez*) (BMNH); 4 ♂ (ex pupae), Merida State, Merida & Timotes (no collection date) (*J. Ramirez*) (BMNH); 5 ♀ 6 ♂ (ex pupae), Miranda State, Guarenas, Rio Izcaragua, Guatire (no collection dates) (*J. Ramirez*) (BMNH).

Taxonomic discussion. Attention was first drawn to *S. lewisi* by Lewis (Lewis, 1963; Lewis & Ibañez de Aldecoa, 1962) during a survey of simuliids as potential vectors of *O. volvulus* in the human onchocerciasis foci in northern Venezuela. Lewis was unable to identify this species due to the inchoate state of the taxonomy of Neotropical Simuliidae at the time and designated it as species A. During his revisionary work on the Venezuelan fauna Ramirez Perez collected *Simulium* species A of Lewis and described it as a new species, *S. lewisi* (Ramirez Perez, 1971). The depository of the holotype is presumed to be the 'Division de Endemias Rurales, Maracay, Venezuela' since the other cited depository, the BMNH, contains only paratypes. Further descriptions and distributional records of *S. lewisi* were subsequently given by Ramirez Perez (1983) and Coscaron (1985).

Coscaron's subsequent descriptions and nomenclatural changes concerning *S. lewisi* and its near relatives *S. iguazuense* and *S. lutzianum* (Coscaron, 1976a, 1985) have caused uncertainty over the status of these three species. The confusion concerns the coloration of the abdominal tergites, which is the only character used to distinguish them. In 1976 Coscaron described the new species *S. iguazuense*, noting the possibility that it might not be distinct from *S. lutzianum*; the females of *S. iguazuense* were described as having the first three abdominal tergites yellowish brown (similar to *S. lewisi*) whereas in males no abdominal segments were yellow (as in *S. lutzianum*). Coscaron (1985) later synonymised *S. iguazuense* with *S. lewisi*, believing that the abdominal tergite coloration of males of these two species varies intraspecifically. In this later paper he records a greater variation in abdominal coloration of male *S. lewisi* but it is not clear in which localities this occurs, and there are inconsistencies in the descriptions of both sexes of this species in the text and keys. Female *S. lewisi* are said to have the first three abdominal segments yellow, whereas in the key segments I–II or III (presumably meaning I–II or I–III) are yellow or yellowish brown. Similarly, male *S. lewisi* are described as having segments I, I–II, II–III or none yellow, whereas in the key I, I–II, or I–III are recorded as yellow. Similar inconsistencies are seen with *S. lutzianum*. The first two abdominal segments of the female are described as light brown in the text whereas in the key the first segment is said to be yellow; in males tergite I is described as brown in the text but light brown in the key. Considering the confusion over this character it is unclear why Coscaron chose *S. lewisi* as the senior synonym of *S. iguazuense* rather than synonymising both *S. iguazuense* and *S. lewisi* with *S. lutzianum*. While we accept his synonymy at this stage the reliability of such colour differences for species separation needs confirmation by using morphological and cytological methods before the status of *S. iguazuense*, *S. lewisi* and *S. lutzianum* is decided.

Variation in abdominal coloration of both female and male *S. lewisi* was seen in our material, usually the first three and rarely the fourth abdominal segments in both sexes being yellow to orange. The male paratype of *S. lewisi* in the BMNH collection shows orange coloration on the first four abdominal segments. The closest relative to *S. lewisi* is *S. lutzianum*, which differs by the presence of yellow coloration only on the first

tergite of the female abdomen and none on the male abdomen. Other closely related species showing coloration differences in the thorax or in pupal gill filament number are *S. alirioi*, *S. gabaldoni*, *S. romanai* Wygodzinsky and *S. adolfolutzi* Wygodzinsky.

Coscaron (1985) includes *S. lewisi* in the subgenus *Ectemnaspis* but we prefer to place it in the closely related subgenus *Psilopelmia*. Whether these taxa should be maintained as valid subgenera awaits further integrated morphological and cytological studies.

Distribution. In Ecuador *S. lewisi* is a common species of the onchocerciasis foci and circumjacent lowland areas on the eastern and western foothills of the Andean cordillera.

Simulium lewisi is widespread in northern Venezuela (Ramirez Perez, 1983). Coscaron (1985) reports *S. lewisi* from Argentina, Bolivia and Peru but the records might refer in some cases to *S. lutzianum* (see taxonomic discussion).

Biology. In Ecuador *S. lewisi* occurs in small shaded streams and in rivers up to 100 m wide in lowland tropical forest either side of the Andean cordillera (Shelley & Arzube, 1985, unpublished data), and in rivers in lowland areas in central and western Venezuela (Ramirez Perez, 1971). The species is apparently totally zoophilic in Ecuador (Shelley & Arzube, 1985) and there are no records of it attacking man elsewhere.

Simulium (Psilopelmia) escomeli Roubaud

(Figs 28, 34, 40, 46, 52, 59, 66, 72, 84, 85, 94, 100, 107, 114, 120, 128, 135, 142, 143, 150, 151)

Simulium escomeli Roubaud, 1909: 428. Syntypes ♀, Peru: Arequipa (no collection date) (*Escomel*) (deposited in MNHN but now lost).
Simulium rufidorsum Enderlein, 1934: 283. Holotype ♀, Peru: (no locality except 'highland area', collection date and collector unknown) (ZM). [Synonymised with *S. escomeli* by Vargas & Dias Najera 1953a: 146.]

Description. *Female.* General body colour brown and grey. Body length (alcohol preserved specimens) 2.1–3.0 mm (n = 24), wing length 2.0–2.5 mm (n = 24), wing width 1.0–1.2 mm (n = 24).

Head dichoptic with red eyes; nudiocular area poorly developed (Fig. 28). Frons, clypeus and occiput grey pollinose. Mouthparts dark brown. Antennae dark brown with basal fourth light brown. Cibarium with unarmed, lightly sclerotised central trough and a group of about 20 fine teeth in two protuberances lateral to this and extending in a single line along base of each sclerotised cornua (Fig. 34).

Scutum chestnut-brown with two submedian vittae, posterior margin and posterior two-thirds of lateral margins of scutum grey pruinose; anterior third of lateral margins of scutum, humeri and anterior scutal border between these and the submedian vittae light brown; the 1 + 1 cunae in the anterior margins of the submedian vittae appear brown with an anterior light source and white pruinose with posterior lighting. Paranotal folds grey pruinose. Scutum with numerous adpressed golden hairs (Fig. 142). Pleural region with light and dark brown areas with faint silver pruinosity. Specimens from high altitudes are darker; the chestnut-brown of the scutum is darker brown, often with areas of black at the interfaces with the grey pruinose areas, and the whole of the pleural region is dark brown with grey pruinosity (Fig. 143). (Similar findings on high altitude Peruvian specimens are reported in Knab (1914a, b).) Scutellum light brown with adpressed golden hairs and an uneven row of upright dark brown hairs on posterior margin. Postnotum dark brown with silvery grey pruinosity.

Subcostal wing vein usually bare but sometimes with up to two hairs on median section, basal section of radius bare (Fig. 40). In specimens from highland areas *Sc* with 4–6 hairs on median section, basal section of *R* usually bare but occasionally with a single hair on median section of vein. Costal base tuft of dark setae.

Legs yellowish with the following areas dark brown: distal articulation of tibia and whole of tarsus of fore leg, external face of tibia faintly pruinose; coxa, distal articulations of femur and tibia, distal half of basitarsus, second tarsomere and rest of tarsus of mid leg; coxa, distal fourth of femur, distal half of tibia, distal half of basitarsus and second tarsomere and rest of tarsus of hind leg. Proportions of legs as in Fig. 142. Claws slender, slightly curved and lacking a basal tooth (Fig. 46). Halteres white with yellowish stem.

Abdominal tergites yellowish grey. Tergal plates (Fig. 4) not obviously developed. Tergite II with median dark brown amorphous spot, tergites III–VI with well-defined central subrectangular black spots; tergites III–VII with pairs of submedian black spots and tergites II–VII with pairs of indistinct sublateral black spots (Fig. 142). Sternites greyish, genitalia brown. Eighth sternite highly sclerotised with a group of 20–25 hairs on each side; gonopophyses small, glabrous, with light sclerotisation on inner margin. Cerci hemispherical, paraprocts with pronounced anterior extension (Fig. 59). Genital fork with well-developed sclerotised anteriorly directed processes and sclerotised stem (Fig. 66). Spermatheca oval as in *S. exiguum* (Fig. 5), highly

sclerotised with no external sculpturing and spicules of inner surface randomly distributed; area of insertion of spermathecal duct membranous, about a third as wide as spermatheca at widest point.

Male. General body colour brown and black, showing variations in different localities. Populations from lowland localities have orange thoraces and in those from highland areas these are generally black but in some instances orange. Body length (alcohol preserved specimens) 2.3–2.8 mm (n = 5), wing length 2.0–2.6 mm (n = 5), wing width 1.0–1.2 mm (n = 5).

Head holoptic with red eyes. Coloration of rest of head as in female except specimens from highland areas which have black antennae with the scape and pedicel orange-brown.

Scutum-orange brown to chestnut in lowland localities. Anterior border of scutum, except for central area and humeri and lateral margins yellowish, posterior margin black as is interface between yellow lateral margin with orange-brown of scutum; a pair of submedian, comma-shaped marks occupy the anterior half of the scutum (Fig. 150). Direction of light source affects the coloration of some of the scutal patterns; with light source posterior to specimen the pair of submedian, comma-shaped marks appear black, curved and almost reach the anterior border but with light source anterior to specimen they appear silver pruinose, are more triangular and adjoin the anterior scutal margin; with light source perpendicular the posterior and lateral margins of the scutum appear silver pruinose. In some specimens the black posterior margin of the scutum extends anteriorly to join the commas. Paranotal folds black. Scutum with adpressed golden hairs. In specimens from most highland localities the orange-brown areas of the scutum are velvet-black (Fig. 151). Pleural region with superior part light brown with faint silver pruinosity and inferior part grey and strongly pruinose. Scutellum light brown with adpressed yellowish hairs and an uneven row of upright dark brown hairs on posterior margin. Postnotum black with silver pruinosity.

Subcostal wing vein and basal section of radius bare. Costal base tuft of dark setae.

Coxa, trochanter, femur and tibia of fore leg light brown, tarsus black; external face of tibia white pruinose. Coxa of mid leg dark brown, trochanter, femur, basal half of basitarsus and of second tarsomere light brown, rest dark brown to black. Coxa of hind leg black, trochanter, basal two-thirds of femur, proximal fourth of tibia and basal half of basitarsus light brown, rest black. Proportions of legs as in Fig. 150. Haltere coloration as in female.

Abdomen and genitalia velvet-black, except tergite II and lateral margins of tergite III which are brown. Basal fringe of first tergite light brown. Silver ornamentation as follows: tergite II silvery white pruinose except for central black spot, tergite V with a pair of submedian silvery white spots, tergite VI silver pruinose and lateral margins of tergite VII silvery pruinose (Fig. 150). In males from highland localities the silvery white areas on tergite V are usually absent. Sternites dull brown with poorly developed sternal plates (Fig. 6) on segments IV–VIII. Gonocoxite one and a half times as long as wide; gonostyle subrectangular, half as long as gonocoxite and with a distal spine (Fig. 72). Ventral plate lightly sclerotised, subrectangular, with well-developed basal arms and a small keel; hairs long and densely distributed over most of ventral plate (Figs 84, 85). Median sclerite elongate, subquadrangular, with a deep incision in apical third (Fig. 94). Paramere with numerous large spines (Fig. 100).

Pupa. Cocoon length dorsally 2.0–3.0 mm, ventrally 2.8–3.4 mm; pupa length 2.0–3.0 mm; gill length 1.6–2.4 mm (n = 40) (all lowland populations).

Cocoon slipper-shaped, dark brown; rim of aperture dark brown, reinforced and without median protuberance (Fig. 107). Cocoon surface of thin, amorphous, elastic substance containing loosely interwoven fibres visible at higher magnifications. Gill light brown with eight, forwardly-directed, slender filaments arranged irregularly in a vertical plane; main trunk giving rise to three primary branches, ventral with two filaments and median and dorsal each with three filaments; ventral branch with bifurcation in basal fourth of gill, median branch with first bifurcation in basal fourth and second bifurcation in basal third of gill; dorsal branch with first bifurcation basally at junction of median and dorsal primary branches and second bifurcation within basal fourth of gill (Fig. 114); filaments slender with crenate margins and rounded distally, their surfaces covered in fine spicules as in *S. exiguum* (Fig. 12). Head as in *S. exiguum* (Fig. 13) with 2 + 2 frontal trichomes, the most dorsal being simple and the more ventral 1–4 branched both poorly developed and 1 + 1 simple or bifid facial trichomes that are small and difficult to distinguish; surface of head covered with platelets as in *S. exiguum*. Thorax as in *S. exiguum* (Fig. 17) with 5 + 5 antero-dorsal poorly developed trichomes with 2–5 branches. Surface of thorax covered with platelets. Abdominal tergite II with 4 + 4 simple hairs, III–IV with 4 + 4 simple hooks,

VI–IX with spine combs on anterior margins, IX with 1 + 1 strong unbranched spines (Fig. 19); sternite IV with 1 + 1 simple or bifid, well-developed outer hooks and 1 + 1 fine inner hairs, V with 2 + 2 simple hooks, VI with 2 + 2 simple hooks, inner pair sometimes bifid and VII with 2 + 2 simple hooks, 1 + 1 patches of spine combs on postero-lateral borders of sternites IV–VIII (Fig. 20).

Mature larva. Body length 4.5–5.3 mm (n = 20). Width of head capsule 0.4–0.5 mm (n = 20). Body colour white with indistinct grey markings (Fig. 120). In specimens preserved in Carnoy's the grey markings appear greyish green. Body form as in Fig. 120.

Head yellow with dark brown markings and occasional setae on all surfaces. Typical head pattern negative as in Fig. 128, with dark areas in form of ring surrounding a median clear area and 1 + 1 postero-lateral clear areas of head spots. Postgenal cleft rounded anteriorly and small relative to the other *Psilopelmia* species (*lewisi* and *bipunctatum*) in the locality; postgenal bridge almost as long as hypostomium (Fig. 135). Hypostomium of type seen in *S. exiguum* (Fig. 21). Antennae long, brown and with segment ratios 12 : 14 : 20. Mandible as in *S. exiguum* (Fig. 23), with two mandibular serrations, the posterior being the larger. Maxillary palp about twice as long as breadth at base. Cephalic fan with 30–32 rays.

Thorax white dorsally, sometimes with a grey band around anterior margin; ventrally with two median patches posterior to proleg. Cuticle glabrous. Proleg plate lightly sclerotised with about ten processes. Pupal respiratory histoblast mid brown and ovoid.

Abdomen white with 1 + 1 dorso-lateral grey patches on first six abdominal segments (5 narrow, 1 wide), posteriorly patches coalesce and cover whole of dorsum of expanded region. Ventrally patches form indistinct bands on anterior six abdominal segments. Ventral nerve cord grey. Occasionally larvae are white and lack grey ornamentation. Larvae from highland localities where dark male forms occur are more variable in coloration; they are darker than those from lowland localities where orange males occur and in some cases the grey patches on the thorax and abdomen coalesce to form a totally grey larva. Cuticle with scattered fine hairs on dorsal surface of posterior segments. Ventral papillae absent. Anal sclerite well sclerotised with posterior arms extending to twelfth row of posterior circlet hooks. Posterior circlet with about 60 rows of 4–14 hooks. Anal gill trilobed as in *S. exiguum* (Fig. 24), usually without secondary lobules; if present, secondary lobules short and up to two on each lateral lobe.

Material examined

Chile: 1 ♀, Valle de Azapa, vi.1912 (*C. E. Porter*) (BMNH); 3 ♀, Valle de Lluta, vi.1912 (*C. E. Porter*) (BMNH).

Ecuador: 3 ♀, Santiago onchocerciasis focus, Rio Onzole, v.1982 (*I. Mera & Platon*) (BMNH); 2 ♀ 4 ♂ (ex pupae), numerous pupae, 4 larvae, Esmeraldas Province, Santo Domingo-Esmeraldas road, Rio Chigwe, 26.ix.1983 (*A. J. Shelley & M. Arzube*) (BMNH, INHMT); 1 ♀ 1 ♂ (ex pupae), 8 pupae, 5 larvae, Santo Domingo-Esmeraldas road, Rio Capli, 26.ix.1983 (*A. J. Shelley & M. Arzube*) (BMNH, INHMT); 1 ♀ 1 ♂ (ex pupae), 8 pupae, 10 larvae, Santo Domingo-Esmeraldas Road, R. Tatica, 26.ix.1983 (*A. J. Shelley & M. Arzube*) (BMNH, INHMT); numerous pupae, Santo Domingo-Esmeraldas Road, R. Achioti, 26.ix.1983 (*A. J. Shelley & M. Arzube*) (BMNH, INHMT); numerous pupae, 2 larvae, Santo Domingo-Esmeraldas road, R. Tabuchi, 26.ix.1983 (*A. J. Shelley & M. Arzube*) (BMNH, INHMT); 1 ♀, near Concordia, road to Puerto Quito, Rio Blanco, 28.ix.1983 (*A. J. Shelley & M. Arzube*) (BMNH); 3 ♂ (ex pupae), numerous pupae and larvae, Esmeraldas-Atacames road, R. Tasechi, 27.ix.1983 (*A. J. Shelley & M. Arzube*) (BMNH, INHMT); 13 ♀ 7 ♂ (ex pupae), Imbabura Province, Salinas road 20 km north of Ibarra, R. Tahuando, 8.ix.1983 (*A. J. Shelley & M. Arzube*) (BMNH, INHMT); numerous females, 15 km south of Juncal on Ibarra road, R. Chota, 7.ix.1983 (*A. J. Shelley & M. Arzube*) (BMNH, INHMT); numerous females, 17 km south of Juncal on Ibarra road, at Engeno Tababuelo, R. Chota, 7.ix.1983 (*A. J. Shelley & M. Arzube*) (BMNH, INHMT); 7 ♀ 5 ♂ (ex pupae), numerous pupae and larvae, Otovalo-Ibarra road, stream opposite Cotacachi turn off, 10.ix.1983 (*A. J. Shelley & M. Arzube*) (BMNH); 1 ♀, Salinas-Lita road, San Juan del Hacha, R. Mira, 11.ix.1983 (*A. J. Shelley & M. Arzube*) (BMNH); 9 ♀, Palacara river, 9.ix.1983 (*A. J. Shelley & M. Arzube*) (BMNH, INHMT); 1 ♀ 2 ♂ (ex pupae), numerous larvae and pupae, nr Ibarra, tributary stream of R. Salado, 11.ix.1983 (*A. J. Shelley & M. Arzube*) (BMNH); 1 ♀ 4 ♂ (ex pupae), numerous larvae and pupae, irrigation canal on Salinas road 4 km from turnoff on Ibarra-Tulcan road, 9.ix.1983 (*A. J. Shelley & M. Arzube*) (BMNH); 1 ♂ (ex pupa), Salinas-Lita road 54 km from Ibarra, R. San Pedro, 11.ix.1983 (*A. J. Shelley & M. Arzube*) (BMNH); numerous pupae, 4 km from Ibarra-Tulcan road, Salinas road, 9.ix.1983 (*A. J. Shelley & M. Arzube*) (BMNH, INHMT); numerous pupae, Salinas-Lita road, 11.ix.1983 (*A. J. Shelley & M. Arzube*) (BMNH, INHMT).

Peru: 15 ♀, Arequipa, [1922] (*Escomel*) (MNHN); 2 ♀, Arequipa (no collection date) (*Escomel*) (BMNH) [presented by E. Roubaud (1923.185)]; 1 ♀ (no collection date or collector's name, but presumed to be Escomel) (BMNH) [presented by Dr Escomel (1919: 259)].

Taxonomic discussion. *Simulium escomeli* was first described by Roubaud (1909) from three female syntypes collected by Escomel in Arequipa, Peru. Roubaud comments on the poor condition of these specimens, which he intended to describe in detail at a later stage once Escomel had obtained more material. The fifteen pinned females in the MNHN are regarded as topotypes as they bear labels indicating the collection locality as Arequipa, the collector E. Escomel and the date 1922; no syntypes were located in this collection and are presumed lost. The two females collected by Escomel from Arequipa and deposited in the BMNH by Roubaud in 1923 (No.1923.185) as well as a third female from the same locality presented in 1919 (No. 1919: 259) are also topotypes.

Later, Enderlein (1934a) gave a superficial description of the nominally new species *S. rufidorsum* from an unnamed highland locality in Peru. Enderlein comments that the holotype was 'through Staudinger'. Staudinger was a lepidopterist and entomological dealer and not the collector (K. S. Sattler, pers. comm.). *Simulium rufidorsum* was synonymised with *S. escomeli* by Vargas & Diaz Najera (1953b) after examination of the holotype female and dissection of its genitalia, which conform to those of *S. escomeli*.

Since Roubaud's preliminary description *S. escomeli* has been redescribed by many authors. The most detailed is that by Wygodzinsky (1971) who lists references to all previous descriptions. (In his work reference to positive head spots on the larval cephalic apotome should read negative.) Wygodzinsky's (1971) work is based on specimens collected in Chile, Peru and Ecuador at high altitude localities. His description completely coincides with the one presented here except that males always possessed black scuta. The colour dimorphism described in this paper, particularly in males, is apparently loosely linked to altitude and appears to be intraspecific; preliminary analysis of polytene chromosomes of larvae from localities pure for males of either colour indicate no obvious differences in their banding patterns (W. S. Procunier, pers. comm.). Further detailed chromosome analysis is underway and will be reported shortly. Although no males, pupae or larvae were found in the lowland forests of the onchocerciasis focus we presume that males are identical to those from adjacent lowland areas and have taken account of this in the identification keys.

Simulium escomeli is the type species of the subgenus *Psilopelmia* Enderlein.

Distribution. *Simulium escomeli* is a common species throughout Ecuador, as indicated by the list of material examined. It is also common in association with the Andean cordillera of western South America in Peru, Chile and Colombia (Knab 1914a; Wygodzinsky, 1971, collections of BMNH, INHMT).

Biology. In Ecuador *Simulium escomeli* bites man voraciously in higher altitude localities but rarely in the western lowlands – despite its omnipresence in the slow-flowing lower reaches of the smaller rivers. In the onchocerciasis focus its breeding grounds have not been located. In higher altitudes it occurs attached to trailing vegetation in both slow – and fast – running small streams.

Simulium escomeli has also been recorded biting man in Chile and Peru where it also breeds in small streams and rivers (Coscaron, 1976b; Wygodzinsky, 1971).

Simulium (Hemicnetha) mexicanum Bellardi

(Figs 15, 16, 18, 22, 29, 35, 41, 47, 53, 60, 67, 73, 86, 87, 95, 101, 108, 115, 121, 129, 136, 144, 152)

Simulium mexicanum Bellardi, 1862 (appendix to part 2): 6. LECTOTYPE ♀, Mexico: Veracruz State, Tuxpango, near Orizaba (collection date and collector unknown) (DBAT), here designated [examined].

Simulium aureopunctatum Malloch, 1914: 27. Holotype ♀, Guatemala: Livingston (6.v. or 5.vi. year not given) (*Barber & Schwarz*) (USNM Cat. No. 15406) [examined]. [Synonymy by Strong *et al.*, 1934: 208.]

Simulium placidum Knab, 1915: 281. Holotype ♀, Trinidad: Arima river, 31.xii.1913 (*F. W. Urich*) (BMNH) [examined]. [Synonymy by Vargas & Diaz Najera, 1951b: 133.]

Simulium lugubre Lutz & Nunez Tovar *in* Lutz, 1928: 46. Syntypes ♀, ♂, l, p, Venezuela: Aragua, Rio de Maracay, La Trinidad, 28.viii.1925 (*A. Lutz & Nunez Tovar*) (IOC) [examined]. [Synonymy by Fairchild, 1940: 708.]

Simulium turgidum Hoffmann, 1930: 298. Syntypes ♀, Mexico: Chiapas State, Soconusco District, Finca Santa Anita (vii.1930) (collector and depository unknown). [Synonymy by Strong *et al.*, 1934: 208.]

DESCRIPTION. *Female*. General body colour black. Body length (alcohol preserved specimens) 3.2–4.0 mm (n = 24). Wing length 2.2–3.6 mm (n = 24), wing width 1.0–1.6 mm (n = 24).

Head dichoptic with red eyes; nudiocular area well-developed (Fig. 29). Frons, clypeus and occiput black with grey pruinosity, covered in numerous black bristles that are longer and denser on upper margin of clypeus and occiput. Proboscis light brown, maxillary palps black. Antennae dark brown with scape, pedicel and first flagellomere orange. Cibarium with large central trough, unarmed; cornuae well-developed and sclerotised (Fig. 35).

Scutum, humeri and paranotal folds black with grey pruinosity. Scutum with numerous, adpressed, short, black setae becoming longer and upright on posterior border, interspersed with clumps of adpressed, brass-coloured scale-like setae (Fig. 144). Pleural region dark brown with grey pruinosity. Scutellum dark brown to black with grey pruinosity and with scattered upright black bristles on whole surface except anterior border and brass-coloured, adpressed, scale-like setae over whole surface. Postnotum black with grey pruinosity.

Subcostal wing vein with an irregular row of setae over entire length; basal section of *R* with three irregular rows of setae along entire length (Fig. 41). Costal base tuft of dark brown setae.

Fore legs with coxae, trochanters, and femora light brown, tibiae white pruinose with apical third and inner margin black, tarsi black. Mid leg coxae dark brown with grey pruinosity, trochanters and femora black, tibiae black with up to basal third light brown, basal two-thirds of basitarsus light brown, rest black, other tarsal segments black. Hind leg coxae dark brown with grey pruinosity, trochanters light brown, femora black, basal third of tibiae white merging to black on apical two-thirds, basal half of basitarsus white, distal half black, rest of tarsi black. Colour and proportions of legs as in Fig. 144. The flattened and widened fore tarsi, mid and hind basitarsi and hind femora and tibiae are typical of *S. mexicanum* and several other species of *Hemicnetha*. Claws curved with subbasal tooth (Fig. 47). Halteres white with black stems.

Basal scale of abdomen (tergite I) velvet-black with long brass-coloured basal fringe, tergite II mottled brown and black with grey pruinosity, tergites III–V velvet-black, tergites VI–IX shiny black (Fig. 144). Tergal plates (Fig. 4) highly sclerotised especially on tergite II. Sternites I and II light brown, rest black. Genitalia black. Eighth sternite well sclerotised with 4–6 setae on each side, gonopophyses well-developed, subtriangular, totally membranous and covered with fine setae (Fig. 53). Cerci hemispherical; paraprocts large and subquadrangular with long bristles and short thick setae (Fig. 60). Genital fork short, strongly sclerotised and with highly developed lateral arms (Fig. 67). Spermatheca oval as in *S. exiguum* (Fig. 5), strongly sclerotised with no external sculpturing and spicules on inner surface randomly distributed; width of membranous area of insertion of spermathecal duct large, about half maximum width of spermatheca.

Male. General body colour black. Body length (alcohol preserved specimens) 3.1–4.5 mm (n = 20), wing length 2.6–3.5 mm (n = 20), wing width 1.1–1.6 mm (n = 20).

Head holoptic with red eyes. Clypeus black with grey pruinosity. Rest of head coloration as in female.

Coloration and setation of scutum, humeri, paranotal folds, pleural region, scutellum and postnotum as in female, except scale-like setae golden and thin dark median line running whole length of scutum, free of these scales (Fig. 152).

Subcostal wing vein and basal section of *R* bare.

Leg coloration and form (Fig. 152) as in female except white area of hind tibia reduced to point of articulation with femur. Halteres as in female.

Basal scale of abdomen (tergite I) velvet-black with dense basal tuft of long black hairs. Tergites II–IX velvet-black with the following silver pruinose ornamentation: tergite II covering whole segment, tergite IV covering anterior border except for median portion, tergites V–VII completely covered except for median triangle on posterior border of each tergite, tergite VIII with a small lateral area on anterior margin of tergite (Fig. 152). Sternites mottled brown and black with poorly developed sternal plates (Fig. 6). Genitalia velvet-black. Gonocoxite rectangular, wider than long, gonostyle elongate with a weakly developed subterminal spine (Fig. 73). Ventral plate rectangular with sclerotised, poorly developed basal arms and a large keel; ventral plate densely covered with fine setae and small spines (Figs 86, 87). Median sclerite elongate with apical depression (Fig. 95). Paramere (Fig. 101) with enlarged basal process and few stout spines apically.

Pupa. Cocoon length 2.5–3.6 mm, ventrally 3.3–4.4 mm; pupa length 3.2–4.3 mm; gill length 1.6–2.5 mm (n = 35).

Cocoon shoe-shaped, mid brown; rim of aperture mid brown, reinforced and without festoons as seen in other *Hemicnetha* species (Fig. 108). Cocoon surface of thin, amorphous, translucent, elastic substance in which thick, interwoven fibres are sometimes visible. Gill light to dark brown,

generally protruding beyond collar of cocoon, with 12 short, forwardly-directed filaments arranged in a bunch. Main trunk of gill giving rise to an inner primary branch bearing five filaments and an outer branch with seven filaments. The filaments arise basally on the gill (Fig. 115), are slender with crenate margins and rounded distally, their surfaces covered with fine spicules as in *S. exiguum* (Fig. 12). Head with 2 + 2 frontal and 1 + 1 facial trichomes, all poorly developed and unbranched; surface of head with platelets which in the frontal region are scattered, enlarged and highly sclerotised and in the facial region are dense and of normal size (Figs 15, 16). Thorax with 5 + 5 antero-dorsal, poorly developed unbranched trichomes. Surface of anterior region of thorax covered in well-developed highly sclerotised platelets which extend to posterior border of thorax either side of raphe and in a pair of submedian and lateral bands to posterior thoracic border which is densely covered by normal size platelets. Ventral surface of thorax without platelets (Fig. 18). Abdominal tergite II with 3 + 3 well-developed simple hooks and 1 + 1 simple fine hairs external to these, III–IV with 4 + 4 simple hooks, IX with no spines, II–IX with 1 + 1 well-developed areas of spine combs on anterior margins and I and II with groups of spine combs on posterior margins (Fig. 19); sternite IV with no hooks or hairs, V–VII with 2 + 2 simple hooks, 1 +1 patches of spine combs on anterior borders of sternites IV–VIII (Fig. 20).

Mature larva. Body length 7.0–9.7 mm (n = 14). Width of head capsule 0.7–0.8 mm (n = 14). Body colour grey in specimens preserved in both alcohol and Carnoy's fixative. Form as in Fig. 121.

Head yellow with dark brown markings and occasional setae on all surfaces. Head pattern positive as shown in Fig. 129, surrounded by dark pigmentation. Occasionally the 1 + 1 lateral groups of head spots are negative in relation to the dark pigmentation of the cephalic apotome in this region. Postgenal cleft bell-shaped and rounded anteriorly (Fig. 136); postgenal bridge almost as long as hypostomium (Fig. 136). Hypostomium (Fig. 22) rounded anteriorly with strongly pigmented anterior margin and nine poorly developed apical teeth; median tooth the most developed with blunt apex, corner teeth smaller and blunt and intermediate teeth poorly defined; 4–5 lateral serrations, hindmost level with first hypostomial seta; 1 + 1 lines of 9–10 hypostomial setae. Antennae long and faintly pigmented with segment ratios 8 : 15 : 10. Mandible with subequal comb teeth and one well-developed backwardly-slanting mandibular serration; a second short mandibular serration sometimes present posterior to the first. Maxillary palp heavily pigmented, brown, about twice as long as width at base. Cephalic fan with 48–60 rays.

Thorax grey dorsally, white ventrally with a large greyish brown patch occupying ventral surface of proleg and a median patch posterior to this. Cuticle with occasional fine hairs on dorsal and ventral surfaces. Proleg plate well sclerotised with about 20 processes. Pupal respiratory histoblast dark brown, claviform.

Abdomen greyish brown dorsally, usually overall, but in some specimens in indistinct bands in anterior constricted abdominal segments; ventrally whitish with irregular grey patches. Ventral nerve cord greyish. Ventral papillae absent (Fig. 121). Cuticle with occasional fine hairs on dorsal and ventral surfaces. Anal sclerite well sclerotised with posterior arms extending to about 65th row of posterior circlet hooks. Posterior circlet with 214– 228 rows of 31–40 hooks. Anal gill trilobed with 12–15 lobules of which one on each lobe is larger than the rest.

Material examined

Lectotype ♀, paralectotype ♀ of *S. mexicanum*, **Mexico**: Veracruz State, Tuxpango, near Orizaba (collection date and collector unknown) (DBAT). Holotype ♀ of *S. aureopunctatum*, **Guatemala**: Livingston, 6.v. or 5.vi. [no year given] (*Barber & Schwarz*) (USNM). Holotype ♀, paratype ♀ of *S. placidum*, **Trinidad**: Arima River, 31.xii.1913 (*E. W. Urich*) (BMNH). Syntypes pupae and larva of *S. lugubre* [only remaining material of syntype series], **Venezuela**: Rio Limon, Maracay (7 pupae), 28.viii.1925 (*A. Lutz & Nunez Tovar*) (IOC, Cat. Nos. 12134, 12173, 12193–12197); Rio Suaire, Caracas (2 pupae), 1925 (*A. Lutz & Nunez Tovar*) (IOC, Cat. No. 12198); no data on label but part of Lutz collection from Venezuela (1 larva) (IOC, Cat. No. 12207).

Belize: 2 ♀ 2 ♂, Hell's Teeth, 15.ii.1958 (*P. C. C. Garnham & D. J. Lewis*) (BMNH).

Colombia: 3 ♀, Norte de Santander, Arboledas, Siravita, La Esperanza, 26.vii.1986 (*B. Alexander*) (BMNH).

Ecuador: 8 ♀ 8 ♂ (ex pupae), 10 larvae, Esmeraldas Province, various localities in the Santiago onchocerciasis focus, San Miguel de Cayapas, Casacadita, R. Cayapa, 17.vi. & 26.v.1981 (*A. J. Shelley & M. Arzube*) (BMNH, INHMT); 1 ♀ (ex pupa), Agua Blanca, R. Cayapa, 15.vii.1986 (*P. Beech-Garwood*) (BMNH); 8 ♀ 10 ♂ (ex pupae), numerous pupae and larvae, Esmeraldas Province, Santo Domingo-Esmeraldas road, Rio Achioti, 26.ix.1983 (*A. J. Shelley & M. Arzube*) (BMNH, INHMT);

numerous pupae and larvae, Santo Domingo-Esmeraldas road, R. Tabuchi, 26.ix.1983 (*A. J. Shelley & M. Arzube*) (BMNH, INHMT); 4 ♀ 2 ♂ (ex pupae), numerous pupae and larvae, Imbabura Province, stream at 40 km from Ibarra on Salinas-Lita road, 11.ix.1983 (*A. J. Shelley & M. Arzube*) (BMNH); 3 ♀ 9 ♂ (ex pupae), numerous pupae and larvae, Salinas-Lita road, R. San Pedro, 11.ix.1983 (*A. J. Shelley & M. Arzube*) (BMNH, INHMT); 1 ♀ 5 ♂ (ex pupae), numerous pupae and larvae, Pichincha Province, Quito-Santo Domingo road, Riachuelo Lelia, 29.ix.1983 (*A. J. Shelley & M. Arzube*) (BMNH, INHMT); numerous pupae and larvae, Quito-Santo Domingo road, R. Toachi, 28.ix.1983 (*A. J. Shelley & M. Arzube*) (BMNH, INHMT).

Guatemala: 1 ♀, Yepocapa onchocerciasis focus, Chimaltenango, Rio Chusita, Finca Chusita, 26.viii.1948 (*H. Dalmat*) (BMNH); 2 ♂, Acatenango, Chimaltenango, Rio El Arco, Finca Chantunjay, 23.x. and 20.xi.1948 (*H. Dalmat*) (BMNH).

Honduras: 2 larvae, Departamento de Cortes, 5 m stream, El Cacao, treatment point, 23.iii.1984 (*L. Lacey*) (BMNH).

Mexico: 2 ♀, Chiapas State, Escuintla, Jalapa aldeia, xi.1935 (collector unknown) (BMNH).

Panama: 12 larvae and 6 pupae, Chiriqui Provence, Boquete, 5.i.1983 (*R. A. Cheke*) (BMNH); 1 pupa, Chiriqui Province, Rio Chiriqui Viejo, 25.ix.1975 (*M. Kerner*) (BMNH); 1 ♂ (ex pupa), 12 larvae and 5 pupae, Cocle Province, El Valle, Rio Anton, La Mapolo, 1–6.vii.1985 (*A. J. Shelley*) (BMNH).

Trinidad: 3 ♀, Naranja, Tucucha Trail, 30.ix.1937 (*J. Smart*) (BMNH); 4 ♀, Blanchisseuse road, 31.x.1937 (*J. Smart*) (BMNH).

Tobago: 5 ♀, Pigeon Peak, 16.x.1937 (*J. Smart*) (BMNH).

Venezuela: 2 ♀, 3 ♂, [northern Venezuela,] La Puerta, 21.v.1961 (*D. J. Lewis*) (BMNH); 1 ♀ 1 ♂, [northern Venezuela,] Rio Aguacatal, 14.vi.1961 (*D. J. Lewis*) (BMNH); 1 ♀, [northern Venezuela,] Monte Oscuro, 6.v.1961 (*D. J. Lewis*) (BMNH); 2 ♀, [northern Venezuela,] Altamira, x.1969 (*W. Büttiker*) (BMNH); 1 ♀ (ex pupa), Carabobo State, Birigina (no collection date) (*J. Ramirez*) (BMNH); 1 ♂ (ex pupa), Lara State, Rio Tocuyo (no collection date) (*J. Ramirez*) (BMNH); 2 ♂ (ex pupae), Federal District, Hacienda El Limon, Divisa Colonia Tovar (no collection date) (*J. Ramirez*) (BMNH).

Taxonomic discussion. Bellardi's description (1862) of *Simulium mexicanum* gives insufficient detail to be able to determine the sex of the material, which he indicates as being male with no reference to number of specimens. The type status of the specimens (holotype or syntypes) is not, therefore, known. No subsequent authors have examined this material because the depository was not known. However, many descriptions of all taxonomically important stages have since been produced, of which that of Dalmat (1955) is the most complete.

Bellardi's collection of Neotropical simuliids has now been located in the University of Turin. *Simulum mexicanum* is represented by two female specimens which are both covered in fungal hyphae but otherwise well preserved; they are easily recognisable as what is currently regarded as this species. The better specimen bears one label with the word 'Tuxpango' and has been designated as lectotype and labelled accordingly. The other specimen with a single label bearing the number '193' has been labelled as paralectotype. It is apparent that Bellardi had confused the sex of his type specimens.

Simulium mexicanum shows little morphological variation given its wide distribution; only the branching height of pupal gills, though basal, can vary within populations.

The synonymies of *S. turgidum* and *S. aureopunctatum* with *S. mexicanum* were first established by Strong *et al.* (1934) although no reasons were given. Hoffmann's description (1930) of *turgidum* and Malloch's (1914) of *aureopunctatum* are sufficiently detailed to show them to be conspecific with the distinctive *S. mexicanum*. An examination of the well-preserved female holotype of *S. aureopunctatum* showed this specimen to completely correspond with our modern concept of *S. mexicanum*, thus confirming their synonymy. The synonymy of *S. lugubre* with *S. mexicanum* is first listed in Fairchild (1940). We have examined the only remaining syntypes (larvae & pupae) in the IOC, which together with the figures and descriptions given by Lutz & Nunez Tovar (Lutz, 1928) all support this synonymy. Vargas & Diaz Najera (1951b) synonymised *S. placidum* with *S. mexicanum* following a comparison of two specimens in the BMNH identified by Smart as *S. placidum* with specimens of *S. mexicanum* from various Latin American localities. Our examination of the holotype of *S. placidum* confirms this synonymy.

In 1934 Enderlein (1934b) described a new species from Mexico as *Hemicnetha mexicana*. Vargas (1942a) did not accept Enderlein's generic classification of the Simuliidae, regarding *Hemicnetha* as a subgenus of *Simulium*, and published the name *paynei* as a replacement name for *mexicanum* Enderlein (junior secondary homonym of *mexicanum* Bellardi).

Simulium mexicanum belongs to the subgenus *Hemicnetha* and is closely related to *S. smarti* Vargas, although females superficially resemble *S. guianense* Wise and *S. orbitale* Lutz in coloration.

DISTRIBUTION. In Ecuador *S. mexicanum* has been found from the western lowlands of the Andes to higher altitudes in the north of the country.

Elsewhere it has been recorded from Belize, Bolivia, Colombia, Guatemala, Mexico, Panama, Tobago, Trinidad and Venezuela (Barreto *et al.*, 1970; Dalmat, 1955; Fairchild, 1940; Knab, 1915; Lewis, 1963; Ramirez Perez, 1983; Smart, 1940; Strong *et al.*, 1934; Vargas, 1945; Vargas & Diaz Najera, 1957; Vargas *et al.*, 1946; Vulcano, 1967).

BIOLOGY. *Simulium mexicanum* is a zoophilic species (Strong *et al.*, 1934; Lewis, 1963; Shelley & Arzube, 1985) which has been reported to bite man occasionally in Colombia (Barreto *et al.*, 1970) and Venezuela (BMNH collection). In Trinidad it bites mules and donkeys (Knab, 1915). *Simulium mexicanum* and *S. metallicum* were originally thought to be associated with the regular transmission of Venezuelan Equine Encephalitis in Colombia (Sanmartin *et al.*, 1973; Zuluaga & Yuill, 1978) but recent evidence (Homan *et al.*, 1985) suggests that at most they only occasionally transmit the virus mechanically.

Simulium mexicanum breeds, often in enormous numbers, in small, fast-flowing streams at both low and high altitudes usually in, or in close proximity to, waterfalls (Barreto *et al.*, 1970; Shelley & Arzube, 1985).

Simulium (Psilopelmia) quadrivittatum Loew

(Figs 30, 36, 42, 48, 54, 61, 68, 74, 88, 89, 96, 102, 109, 116, 122, 130, 137, 145, 153)

Simulium quadrivittatum Loew, 1862: 186. LECTOTYPE ♀, CUBA: (collection date unknown) (*Gundlach*) (MCZH, Cat. No. 12533), here designated [examined].

Wilhelmia mallochi Enderlein, 1925: 208. LECTOTYPE ♀, COSTA RICA: La Palma, 6.v. (no year cited) (*Biolley*) (USNM, Cat. No. 8998, Type No. 41595), here designated [examined]. [Synonymy by Vargas, 1945: 189.]

Simulium fairchildi Vargas, 1942b: 458. LECTOTYPE ♀, PANAMA: Juan Mina Station, Rio Chagres, 8.xi.1939 (*G. B. Fairchild*) (MCZH), here designated [examined]. [Replacement name for *S. haematopotum* Malloch sensu Fairchild, 1940.] [Synonymised with *S. quadrivittatum* by Fairchild, 1943: 574.]

DESCRIPTION. *Female*. General body colour black. Body length (alcohol preserved specimens) 2.0–2.7 mm (n = 55), wing length 1.6–2.2 mm (n = 55), wing width 0.7–1.0 mm (n = 55).

Head dichoptic with red eyes; nudiocular area well-developed (Fig. 30). Frons, clypeus and occiput black with silver pruinosity. Mouthparts dark brown. Antennae orange-brown. Cibarium with sclerotised posterior margin armed with teeth; median area of margin concave with three stout teeth, a pair of submedian groups of about six well-developed teeth with the central being longer and up to tricusped; posterior margin of cibarium between these teeth and cornuae occupied by three to five smaller teeth; cornuae well-developed and sclerotised (Fig. 36).

Scutum velvet-black with silver pruinose ornamentation, which varies in form depending on angle of illumination. With light source anterior to specimen silver ornamentation as follows: a pair of parallel, submedian bands narrowing posteriorly and running from the anterior scutal border and coalescing with the silver pruinose posterior border, a pair of dull grey cunae in form of equilateral triangles present in anterior section of these bands; a pair of sublateral parallel bands beginning at the golden pruinose humeri and extending to posterior pruinose margin of scutum (Fig. 145). With light source posterior to specimen the grey cunae become silver and merge with the submedian bands, the rest of the pattern being identical to that seen with an anterior light source. Irrespective of direction of light source *S. quadrivittatum* is unique in that the submedian pruinose bands show a constriction at the posterior border of the cunae, which readily distinguishes it from *S. haematopotum* and similarly ornamented species of the *amazonicum* group. Paranotal folds black with silver pruinosity. Scutum with numerous adpressed golden hairs. Pleural region dark brown with faint silver pruinosity. Scutellum velvet-black with an uneven row of long black bristles on posterior border and a group of these bristles on each postero-lateral corner. Postnotum black with grey pruinosity.

Subcostal vein of wing usually bare but sometimes with up to two hairs on median section and more rarely a single hair at base of vein amongst sensilla; basal section of radius bare (Fig. 42). Costal base tuft of dark setae.

Legs dark brown with coxae lightly grey pruinose; distal tip of femur and basal tip of tibia light brown at articulation on fore leg; distal tip of femur of mid leg and basal half of basitarsi and second tarsomeres cream; basal articulation of tibiae, basal half to two-thirds of basitarsi and basal half of second tarsomeres of hind leg cream. Proportions of legs as in Fig. 145. Femora and tibiae of all legs and trochanters of fore and hind

legs with numerous scales scattered amongst hairs as in *S. exiguum* (Fig. 3). Claws curved with subbasal tooth (Fig. 48). Halteres bright yellow with light brown base.

Abdominal tergites black. Tergal plates slightly developed (Fig. 4). Basal scale (tergite I) velvet-black, sometimes with faint silver pruinosity in central part; tergite II black with silver pruinosity; tergites III–V velvet-black with posterior margins faintly silver pruinose; tergites VI–IX shiny black. Sternites and genitalia dull black (Fig. 145). Eighth sternite sclerotised with a group of 8–10 setae on each side, gonopophyses large, subquadrangular with numerous minute setae (Fig. 54). Cerci hemispherical, paraprocts small and subrectangular (Fig. 61). Genital fork stout with well-sclerotised stem, expanded arms and well-developed lateral wings with sclerotised anterior processes (Fig. 68). Spermatheca as in *S. exiguum* (Fig. 5), oval, sclerotised with no external sculpturing and spicules of inner surface arranged in groups of three. Area of insertion of spermathecal duct membranous and about one-third maximum width of spermatheca.

Male. General body colour black. Body length 2.6 mm (alcohol preserved specimen) (n = 1), wing length 1.8 mm (n = 1), wing width 0.9 mm (n = 1).

Head holoptic with dark red eyes. Clypeus black with silver pruinosity. Rest of head coloration as in female.

Scutum velvet-black with a pair of submedian silver cunae extending from anterior scutal border for about two-thirds of its length (most easily seen with light source anterior to specimen). Posterior border and anterior three-fourths of lateral border of scutum silver pruinose. Scutum with adpressed golden hairs. Paranotal fold velvet-black (Fig. 153). Coloration and setation of pleural region, scutellum and postnotum as in female.

Subcostal vein and basal section of *R* bare.

Leg coloration as in females, proportions as in Fig. 153. Scale distribution on legs as in female. Haltere coloration as in female.

Abdominal tergites velvet-black, basal fringe of long black hairs. Silver pruinose ornamentation as follows: tergite II completely silver, tergites III, V and VI completely silver except for median dark patch (Fig. 153). Sternites and genitalia dark brown, sternal plates not examined (lack of material). Gonocoxite slightly longer than wide; gonostyle subtriangular, about half length of basimere, with subterminal, rounded spine (Fig. 74). Ventral plate as in Figs 88, 89 with highly developed lightly sclerotised basal arms and poorly developed keel; hairs long and restricted to keel; median plate slightly pyriform with small apical incision (Fig. 96). Paramere as in Fig. 102 with several well-developed distal spines.

Pupa. Cocoon length dorsally 1.8 mm, ventrally 2.6 mm; pupa length 2.5 mm; gill length 3.6 mm (n = 1).

Cocoon slipper-shaped, dark brown opaque; rim of aperture dark brown, reinforced and sometimes with dorsal protuberance (Fig. 109). Cocoon surface of thin, densely interwoven fibres. Gill mid brown with eight, forwardly-directed, long, slender filaments; primary branches arise in the vertical plane with filaments arranged in the horizontal plane. The gill configuration description is from a slide-mounted specimen (Fig. 116); main trunk giving rise to three primary branches, inner (= ventral) with two filaments and median and outer (= dorsal) each with three filaments; inner branch with bifurcation at basal sixth of gill, median branch with first bifurcation at basal sixth and second at basal third, outer branch with first bifurcation at basal tenth and second bifurcation at basal sixth of gill; filaments slender with crenate margins and rounded distally, their surfaces covered with fine spicules as in *S. exiguum* (Fig. 12). Head as in *S. exiguum* (Figs 13, 14) with 2 + 2 bifid frontal and 1 + 1 simple well-developed facial trichomes; surface of head glabrous with few platelets. Thorax as in *S. exiguum* (Fig. 17) with 5 + 5 well-developed, bifid, antero-dorsal trichomes. Surface of thorax with few platelets. Abdominal tergite II with a line of 4 + 4 fine hairs, III–IV with 4 + 4 simple hooks, IX with 1 + 1 well-developed spines, VI–IX with a row of well-developed spine combs on anterior margins of segments (Fig. 19); sternite IV with 2 + 2 simple or bifid well-developed hooks, V–VII with 2 + 2 bifid or trifid hooks, sternite VIII with 1 + 1 antero-median patches of spine combs (Fig. 20).

Mature larva. Body length 3.4–4.5 mm (n = 6). Width of head capsule 0.4 mm (n = 6). Body colour white with grey banding (Fig. 122). Body form as in Fig. 122. This species is easily confused with *S. lewisi* but can be distinguished by the form of the postgenal cleft and the presence of ventral papillae. Larval coloration in Carnoy's fixative was not observed due to paucity of material.

Head yellow with head spots concolorous or forming a positive pattern as in Fig. 130 and with sparsely distributed setae on all surfaces. Postgenal cleft small, triangular with thickened lateral margins; postgenal bridge as long as hypostomium (Fig. 137). Hypostomium as in *S. exiguum* (Fig. 21). Antennae long, yellow to pale brown with

segment ratios 15 : 20 : 25. Mandible as in *S. exiguum* (Fig. 23). Maxillary palp over three times as long as width at base. Cephalic fan with 36–40 rays. Thorax white with black collar anteriorly, amorphous, grey patches dorsally and several small, black patches ventrally posterior to proleg. Cuticle glabrous ventrally but with occasional setae dorsally. Proleg plate not observed (insufficient specimens). Pupal respiratory histoblast dark brown and claviform.

Abdomen white with a single black ring on first abdominal segment and on last narrow abdominal segment, intermediate segments with incomplete rings usually more obvious dorsally; posterior segments of abdomen with dark patches distributed randomly, but dorsally these coalesce. Ventral nerve cord grey. Cuticle with scattered setae on dorsal surface of anterior (narrow) constricted segments, more densely distributed on posterior (wide) segments, glabrous ventrally. Ventral papillae well-developed (Fig. 122). Anal sclerite well sclerotised with posterior arms extending to twelfth row of posterior circlet hooks. Posterior circlet with 58 rows of 10–11 hooks. Anal gill trilobed as in *S. exiguum* (Fig. 24) with six short lobules on each lobe.

Material examined

Lectotype ♀ and paralectotype ♀ of *S. quadrivittatum*, **Cuba**: collection date unknown (*Gundlach*) (MCZH). Lectotype ♀ and paralectotype ♀ of *Wilhelmia mallochi*, **Costa Rica**: La Palma, 6.v. (no year given) (*Biolley*) (USNM) and 2 paralectotype ♀ of *Wilhelmia mallochi*, **Cuba**: Cayamas, 6.vi., 10.vi. (no year given) (*E. A. Schwarz*) (USNM). Lectotype ♀ and 4 paralectotype ♀ of *S. fairchildi*, **Panama**: Juan Mina, Rio Chagres, Canal Zone, 8.xi.1939 (*G. B. Fairchild*) (MCZH), 2 paralectotype ♀ and 1 paralectotype ♂ of *S. fairchildi*, **Panama**: Summit, Canal Zone, 9.i.1940 (*G. B. Fairchild*) (MCZH) and the following female paralectotypes of *S. fairchildi*, **Panama**: 2 ♀, Forest Reserve, Canal Zone, 11.x.1939; 1 ♀, Las Guacas, Panama Republic, 4.i.1940; 1 ♀, Chilibre, Panama Province, Panama Republic, 23.xi.1939 (all *G. B. Fairchild*) (MCZH).

Belize: 46 ♀, Privation Creek, 31.ii.1958 (*D. J. Lewis*) (BMNH); 3 ♀, Cool Shade, 11.i.1958 (*D. J. Lewis & P. C. C. Garnham*) (BMNH); 6 ♀, Middlesex, 8 & 17.ii.1958 (*D. J. Lewis*) (BMNH), 1 ♀, North Branch, 10.ii.1958 (*D. J. Lewis*) (BMNH); 3 ♀, Rio Frio, 5.ii.1958 (*P. C. C. Garnham & D. J. Lewis*) (BMNH); numerous females, near Cayo, Augustine, 27.vii.1961 (*D. J. Lewis*) (BMNH).

Colombia: 1 ♀, Choco, El Tigre, x.1959 (*P. C. C. Garnham*) (BMNH).

Costa Rica: 5 ♀, Env. da Cartago & La Palma, 1500 m, 1906 (*Biolley*) (MNHN) [1 ♀ in BMNH from Env. da Cartago presented by Roubaud with incomplete data but almost certainly from the series deposited by Biolley in MNHN]; 1 ♀, Talamanca, 22.iv.1917 (*C. B. Williams*) (BMNH); 4 ♀, Orosi, 6.i.1938 (*K. W. Kamm*) (BMNH).

Ecuador: 9 ♀, Esmeraldas Province, various localities in the Santiago onchocerciasis focus, San Miguel de Cayapas, R. Cayapa 18–21.vi.1981 (*A. J. Shelley & M. Arzube*) (BMNH, INHMT); 7 ♀, R. Cayapas, 28.vi.1980 (*M. Arzube*) (BMNH, INHMT); 5 ♀, San Miguel de Cayapas, R. Cayapa, 28–30.vi.1980 (*M. Arzube*) (BMNH, INHMT); 6 larvae, San Miguel de Cayapas, Estero Hacha, 26.v.1981 (*A. J. Shelley & M. Arzube*) (BMNH); 1 ♀ (ex pupa), San Miguel de Cayapas, R. Cayapa, Cascadita, 17.vi.1981 (*A. J. Shelley & M. Arzube*) (BMNH); 1 ♂ (ex pupa), 500 m above San Miguel de Cayapas, feeder stream of R. San Miguel, 17.vi.1981 (*A. J. Shelley & M. Arzube*) (BMNH); 1 ♀, Sapallo Grande Mission, R. Cayapa, 28.v.1981 (*A. J. Shelley & M. Arzube*) (BMNH); 3 ♀, Naranjal, R. Canandé, 25.ix.1983 (*A. J. Shelley & M. Arzube*) (BMNH); 1 ♀ (ex pupa), 2 larvae, Naranjal (R. Canandé), R. Aguas Negras, 23.vi.1985 (*A. J. Shelley & M. Arzube*) (BMNH); 1 ♀, 1 ♀ (ex pupa), Cotopaxi Province, Quevedo-La Mana-Pilalo road, La Germania, Riachuelo, 9.vi.1984 (*A. J. Shelley & M. Arzube*) (BMNH); 1 ♀, Manabi Province, Santa Domingo-El Carmen road, km 40, 2 km past El Carmen, Rio Suma, 7.vi.1984 (*A. J. Shelley & M. Arzube*) (BMNH); 2 ♀, El Oro Province, Machala-Naranjal road, Rio Bucay, 12.vi.1984 (*M. Arzube*) (BMNH).

Jamaica: 1 ♀, (no locality or collection date) (*H. G. Johnston*) (BMNH).

Mexico: 1 ♀ 1 ♂, Las Chuapas, ii.1947 (*J. Parra*) (BMNH).

Panama: 8 ♀, Canal Zone, 1932 (*L. H. Dunn*) (BMNH); 3 ♀, 1 ♀ (ex pupa), Chiriqui Province, Fortuna hydroelectric station, Arroyo 47, Q10 E27 and Q47 CUSA, 18.x.1979, 18.iii.1980 & 22.i.1981 (*J. L. Petersen*) (BMNH).

Taxonomic discussion. *Simulium quadrivittatum* was described by Loew (1862) from females collected in Cuba, with no details of the number of specimens examined or their depository. However, Smart (1942) noted the presence of two syntypes in the MCZH (depository incorrectly cited as in Berlin and not Harvard) where all of Loew's New World Diptera types were deposited. This material has now been examined and the better

specimen designated as lectotype and labelled accordingly. Many descriptions and misidentifications of *S. quadrivittatum* have been made and these are listed with the most complete descriptions of this species by Wygodzinsky (1953), Rubtsov & Garcia Avila (1972) and Fox (1953). *Simulium quadrivittatum* is most closely related to *S. haematopotum* in the subgenus *Psilopelmia* and in female coloration resembles *S. marathrumi* Fairchild, *S. oyapockense* Floch & Abonnenc, *S. roraimense* Nunes de Mello and *S. sanguineum* Knab of the subgenus *Psaroniocompsa*.

In his revision of the Simuliidae of the Americas, Malloch (1914) gave a detailed description of *S. quadrivittatum* based on material from Cuba, Costa Rica, Puerto Rico and Panama in the USNM. Enderlein (1925) later described the specimens from Cuba and Costa Rica as a new species, *Wilhelmia mallochi*, although it is unclear whether he saw Malloch's material. *Wilhelmia mallochi* was later synonymised with *S. quadrivittatum* by Vargas (1945) but with no explanation for this action. Pinned specimens of *W. mallochi* in the USNM have now been examined. They consist of two females labelled as cotypes from La Palma, Costa Rica, collected by Biolley, a female 'cotype' from Cayamas, Cuba, collected by Schwarz in June (specimen and collection year missing), and two further females from Cayamas collected in the same period by Schwarz but with no 'cotype' labels. The better specimen from La Palma of these four syntypes has been designated lectotype. The lectotype and paralectotypes of *Wilhelmia mallochi* have been compared with the lectotype of *S. quadrivittatum* and are conspecific. The specimens in the BMNH and MNHN collected in La Palma by Biolley are almost certainly from the same collection as those examined by Malloch in the USNM. However, they did not form part of the syntype series of *W. mallochi* because they were not cited by Malloch (1914) on which publication Enderlein (1925) presumably based his new species. In Fairchild's (1940) revision of the Simuliidae of Panama a description of the female, male and pupa of *S. haematopotum* were given although the author discussed the possibility that this was a misidentification. He noted differences between his material and the figures of this species by Dyar & Shannon (1927), the similarity of his material to *S. pseudohaematopotum* Hoffmann, and that a previous worker in the area had identified this species as *S. quadrivittatum*. Later, Vargas (1942b) proposed the name *fairchildi* for Fairchild's specimens because of differences they showed in the genital fork and claw with *S. haematopotum* and in the genital fork of *S. haematopotum*. Fairchild (1943) later examined true *S. haematopotum* and concluded that *S. fairchildi* should be regarded as a synonym of *S. quadrivittatum* until material from the type locality (Cuba) of the latter species could be examined. Vargas (1945) maintained this synonymy. Fairchild's description and figures of *S. fairchildi* (as *S. haematopotum* in Fairchild, 1943) indicates *S. quadrivittatum* and not *S. haematopotum* with reference to the toothed claw and pupal gill. Fairchild's material has now been examined and currently comprises the material listed as *S. fairchildi* under material examined. A lectotype from Juan Mina, Rio Chagres has been selected from this syntype series and together with the paralectotypes is conspecific with the lectotype of *S. quadrivittatum*. The male paralectotype of *S. fairchildi* from Summit, Panama, has been compared with a reared *S. quadrivittatum* from Ecuador and is conspecific. We therefore agree with the synonymy of *S. fairchildi* with *S. quadrivittatum* first proposed by Fairchild (1943). Various other misidentifications of *S. quadrivittatum* as *S. haematopotum* are listed by Vulcano (1967) and Wygodzinsky (1953).

Distribution. In Ecuador *S. quadrivittatum* inhabits lowland forested areas and plantations to the west of the Andean cordillera and only occurs in large numbers in the onchocerciasis focus in the north of the country (Shelley & Arzube, 1985; Leon & Wygodzinsky 1953a, b; Wygodzinsky 1953). Outside Ecuador *S. quadrivittatum* has been recorded from Belize (Lewis & Garnham, 1960), Colombia (BMNH), Costa Rica (Roubaud, 1906), Cuba (Rubtsov & Garcia Avila, 1972), Jamaica (BMNH), Mexico (Vargas & Diaz Najera, 1957), Panama (Petersen *et al.*, 1983) and Puerto Rico (Fox, 1953), sometimes at high altitudes (Lewis & Garnham, 1960; Petersen *et al.*, 1983). The inclusion of Venezuela by Vargas (1945) in his distribution list for *S. quadrivittatum* is presumably based on Ortiz (1944). However, Ramirez Perez (1983) believes that a member of the *S. amazonicum* group (subgenus *Psaroniocompsa*) and not *S. quadrivittatum* was involved.

Biology. *Simulium quadrivittatum* is highly anthropophilic in Ecuador (Shelley & Arzube, 1985) and Central America (Fox, 1953; Lewis & Garnham, 1960; Rubtsov & Garcia Avila, 1972; Petersen *et al.*, 1983), but also bites equines (Vargas, 1945). *Simulium quadrivittatum* is only of medical importance in Ecuador where it is a vector of human onchocerciasis (Shelley, 1988; Shelley & Arzube, 1985). In Panama it was a biting nuisance during the construction of a dam in Chiriqui Province (Petersen *et al.*, 1983), and has been shown to be a suitable experimental host to

Guatemalan *O. volvulus* (Schiller *et al.*, 1984), although human onchocerciasis has not been recorded from Panama. It breeds in slow-flowing streams and shows population peaks in the wet season (Lewis & Garnham, 1960; Petersen *et al.*, 1983; Rubtsov & Garcia Avila, 1972; Shelley & Arzube, 1985).

REFERENCES

Arzube, M. E. 1981. Onchocerciasis endemic in Ecuador. WHO/ONCHO/81.155. World Health Organization. Mimeographed document. 4 pp.

Arzube R., M. E. 1982. Oncocercosis en el Ecuador. Primer foco descubierto en el pais, hallazgos clinicos, parasitologicos i entomologicos. *Tropenmedizin und Parasitologie* **33:** 45–50.

Barreto, P., Trapido, H. & Lee, V. H. 1970. Onchocerciasis in Colombia. Entomologic findings in the first observed focus. *American Journal of Tropical Medicine and Hygiene* **19:** 837–841.

Bellardi, L. 1862. *Saggio di ditterologia messicana. Appendice.* 28 pp. Torini. [This is a separately issued and paginated Appendix to Bellardi's Part I (1861) and Part II (1862) of *Saggio di ditterologia messicana*. It predates its subsequent issue in a journal, see Bellardi, 1865.]

—— 1865. Saggio di ditterologia messicana. Parte II [incl. Appendice]. *Memorie della Reale Accademia delle Scienze di Torino* (2) **21** (1864): 103–225. [This work is usually wrongly dated 1864 but the original wrapper of the journal part bears the issue date 1865. The journal is for the nominal year 1864. Pp. 200–225 constitute the 'Appendice'. Both the body of Parte II and the Appendice were independently issued in 1862 in advance of the journal. See Bellardi, 1862.]

Coscaron, S. 1976a. Notas sobre simulidos neotropicales VI. Sobre dos especies nuevas de jejenes de la provincia de Misiones, Argentina (Diptera, Insecta). *Revista de la Sociedad Entomologica Argentina* **35:** 147–154.

—— 1976b. Las especies de 'jerjeles' (Simuliidae, Diptera, Insecta) de la zona de Arica. *Idesia* **4:** 25–34.

—— 1985. Revision del subgenero *Simulium (Ectemnaspis)* Enderlein (Simuliidae, Diptera, Insecta). *Revista de la Sociedad Entomologica Argentina* **43:** 283–325.

Coscaron, S. & Wygodzinsky, P. 1975. Notas sobre simulidos neotropicales V. Aportes para el conocimiento del subgenero *Simulium (Notolepria)* Enderlein (Diptera-Simuliidae). *Revista de la Sociedad Entomologica Argentina* **34 (1973–74):** 277–288. [Printer's note in journal indicates publication date as 1975.]

Crosskey, R. W. 1969. A re-classification of the Simuliidae (Diptera) of Africa and its islands. *Bulletin of the British Museum (Natural History),* (Entomology) Supplement **14:** 1–195.

—— 1987. An annotated checklist of the world black flies (Diptera: Simuliidae), pp. 425–520. *In* Kim, K. C. & Merritt, R. W. (Eds), *Black flies: ecology, population management and annotated world list* xv + 528 pp. London.

—— (In press). The vectors of human onchocerciasis and their biology. *In* Nelson, G. S. & Mackenzie, C. D. (Eds), *Human onchocerciasis*. London.

Dalmat, H. T. 1955. The black flies (Diptera, Simuliidae) of Guatemala and their role as vectors of onchocerciasis. *Smithsonian Miscellaneous Publications* **125:** vii + 425 pp.

Dampf, P. 1944. The occurrence of two male forms, dichoptic and holoptic, in *Simulium exiguum* Roubaud (Diptera, Simuliidae). *Canadian Entomologist* **76:** 117–124.

Diaz Najera, A. 1961. Nota acerca de *Simulium (Psilopelmia) antillarum* Jennings, 1915. Nueva especie para Mexico. (Diptera, Simuliidae). *Revista del Instituto de Salubridad y Enfermedades Tropicales* **21:** 79–92.

Dyar, H. G. & Shannon, R. C. 1927. The North American two-winged flies of the family Simuliidae. *Proceedings of the United States National Museum* **69:** 1–54.

Enderlein, G. 1925. 2. Weitere Beiträge zur Kenntnis der Simuliiden und ihrer Verbreitung. *Zoologischer Anzeiger* **62:** 201–211.

—— 1934a. Weiterer Ausbau des Systems der Simuliiden. (Dipt.). *Deutsche Entomologische Zeitschrift* **1933:** 273–292.

—— 1934b. Aussereuropäische Simuliiden aus dem Wiener Museum. *Sitzungsberichte der Gesellschaft naturforschender Freunde Berlin* **1934:** 190–195.

Fairchild, G. B. 1940. Notes on the Simuliidae of Panama (Dipt., Nematocera). *Annals of the Entomological Society of America* **33:** 701–709.

—— 1943. An annotated list of the bloodsucking insects, ticks and mites known from Panama. *American Journal of Tropical Medicine* **23:** 569–591.

Floch, H. & Abonnenc, E. 1946. Simulides de la Guadeloupe: *S. antillarum* Jennings et *S. tarsale* Williston. *Publication de l'Institut Pasteur de la Guyane et du Territoire de l'Inini* **130:** 1–6.

Fox, I. 1953. Notes on Puerto Rican Simuliidae from light traps (Diptera). *Proceedings of the Entomological Society of Washington* **55:** 135–140.

Gibson, C. L. & Dalmat, H. T. 1952. Three new potential intermediate hosts of human onchocerciasis in Guatemala. *American Journal of Tropical Medicine & Hygiene* **1:** 848–851.

Guderian, R. H., Molea, J., Swanson, D., Proano, E., Carrillo, R. & Swanson, W. L. 1983. Onchocerciasis in Ecuador. I. Incidence and distribution in the Province of Esmeraldas. *Tropenmedizin und Parasitologie* **34:** 143–148.

Guttman, D. 1972. The biting activity of black flies (Diptera: Simuliidae) in three types of habitats in western Colombia. *Journal of Medical Entomology* **9:** 269–276.

Hoffmann, C. C. 1930. Los simulidos de la region onchocercosa de Chiapas (con descripcion de nuevas especies). *Anales del Instituto de Biologia del Universidad Nacional Autonoma, Mexico* **1:** 293–306.

Homan, E. J., Zuluaga, F. N., Yuill, T. M. & Lorbacher de R., H. 1985. Studies on the transmission of Venezuelan Equine Encephalitis virus by Colombian Simuliidae (Diptera). *American Journal of Tropical Medicine and Hygiene* **34:** 799–804.

Jennings, A. H. 1915. Two new species of *Simulium* from tropical America. *Proceedings of the Entomological Society of Washington* **17:** 199–200.

Joan, J. 1912. Nota sobre un diptero ponzonoso. *Boletin del Ministerio de Agricultura de Buenos Aires* **14:** 363–385.

Knab, F. 1913. A note on some American Simuliidae. *Insecutor Inscitiae Menstruus* **1:** 154–156.

—— 1914a. Simuliidae of Peru. *Proceedings of the Biological Society of Washington* **27:** 81–85.

—— 1914b. Supplementary notes on Peruvian Simuliidae. *Proceedings of the Biological Society of Washington* **27:** 123–124.

—— 1915. Some new Neotropical Simuliidae. *Bulletin of Entomological Research* **6:** 279–282.

Leon, L. A. & Wygodzinsky, P. 1953a. Los simulidos del Ecuador y su importancia en medicina Tropical (Diptera Simulidae [*sic*]) *Revista Ecuatoriana de Entomologia y Parasitologia* **1:** 23–39 [+ ii].

—— 1953b. Los simulidos del Ecuador (Dipteria [*sic*]), su importancia en medicina humana. *Boletin de Informaciones Cientificas Nacionales, Quito* **6:** 269–288. [This is virtually the same work as Leon & Wygodzinsky (1953a) but differs slightly in title and in the absence of an English summary.]

Levi-Castillo, R. 1956. Provisional list of the Culicidae, Simuliidae, *Phlebotomus* and *Culicoides* of Ecuador. *Proceedings of the Tenth International Congress of Entomology* **3:** 867–871.

Lewis, D. J. 1963. Simuliidae (Diptera) from the human onchocerciasis area of Venezuela. *Proceedings of the Royal Entomological Society of London* (B) **32:** 53–62.

Lewis, D. J. & Garnham, P. C. C. 1960. The Simuliidae (Diptera) of British Honduras. *Bulletin of Entomological Research* **50**: 703– 710.

Lewis, D. J. & Ibañez de Aldecoa, R. 1962. Simuliidae and their relation to human onchocerciasis in northern Venezuela. *Bulletin of the World Health Organization* **27:** 449–464.

Lewis, D. J. & Lee-Potter, J. P. 1964. Simuliidae (Diptera) from the Sierra Nevada de Santa Marta, Colombia. *Annals and Magazine of Natural History* (13) **7:** 95–100.

Loew, H. 1862. Diptera Americae septentrionalis indigena. Centuria secunda. *Berliner Entomologische Zeitschrift* **6:** 185–232. [Later republished (pp. 55–102) in 1864 in *Diptera Americae septentrionalis indigena. 1 (Centuriae 1–5):* 266 pp. Berlin [1861].]

Lutz, A. 1928. *Estudios de Zoologia y Parasitologia Venezolanos* [1–5] 6–133 pp. 25 pls. Rio de Janeiro.

Malloch, J. R. 1912. One new genus and eight new species of dipterous insects in the United States National Museum collection. *Proceedings of the United States National Museum* **43:** 649–658.

—— 1914. American black flies or buffalo gnats. *Technical Series of the Bureau of Entomology, United States* **26:** 19–71 + [xii].

Ortiz, I. 1944. *Simulium quadrivittatum* Loew. Su presencia en Venezuela. *Boletin del Laboratorio de la Clinica Luis Razetti* **4:** 243–246.

Paterson, G. & Shannon, R. C. 1927. Los simulidos del Noroeste Argentino. *Revista del Instituto Bacteriologico del Departamento Nacional de Hygiene* **4:** 737–742.

Petersen, J. L., Adames, A. J. & De Leon, L. 1983. Bionomics and control of black flies (Diptera: Simuliidae) at the Fortuna hydroelectric project, Panama. *Journal of Medical Entomology* **20:** 399–408.

Procunier, W. S., Shelley, A. J. & Arzube, M. 1985. Sibling species of *Simulium exiguum* (Diptera: Simuliidae), the primary vector of onchocerciasis in Ecuador. *Revista Ecuatoriana de Hygiene y Medicina Tropical* **35:** 49–59.

Ramirez Perez, J. 1971. Distribucion geografica y revision taxonomica de los simulidos (Diptera: Nematocera) de Venezuela con descripcion de diez especies nuevas. *Acta Biologica Venezolana* **7:** 271–371.

—— 1983. *Los jejenes de Venezuela*. 156 pp. Supplement originating from *Simposio de Oncocercosis Americana*. Caicet, Puerto Ayacucho, 15–17 octubre 1983.

Ramirez Perez, J., Yarzabal, L. & Peterson, B. 1982. La simuliofauna del Territorio Federal Amazonas (Venezuela). *Publicacion Cientifica* **1:** 1–104.

Ramirez Perez, J. & Vulcano, M. A. 1973. Descripcion y redescripciones de algunos simulidos de Venezuela (Diptera: Simuliidae). *Archivos Venezolanos de Medicina Tropical y Parasitologia Medica* **5:** 375–399.

Roubaud, E. 1906. Simulies nouvelles de l'Amerique du Sud. *Bulletin du Muséum d'Histoire Naturelle* **12:** 106–110.

—— 1909. Description d'une simulie nouvelle du Perou. *Bulletin de la Société de Pathologie Exotique, Paris* **2:** 428– 430.

Rubtsov, I. A. & Garcia Avila, I. 1972. Los simulidos de Cuba (Diptera: Simuliidae). *Poeyana* **96:** 1–39.

Sanmartin, C., Mackenzie, R. B., Trapido, H., Barreto, P., Mullenax, C. H., Gutierrez, E. & Lesmes, C. 1973. Encefalitis Equina Venezolana en Colombia, 1967. *Boletin de la Oficina Sanitaria Panamericana* **64:** 108–137.

Schiller, E. L., Petersen, J. L., Shirazian, D. & Figueroa Marroquin, H. 1984. Morphogenesis of larval *Onchocerca volvulus* in the Panamanian black fly, *Simulium quadrivittatum*. *American Journal of Tropical Medicine & Hygiene* **33:** 410–413.

Shelley, A. J. 1988. Vector aspects of the epidemiology of onchocerciasis in Latin America. *Review of Applied Entomology* **30:** 337–366.

—— In press a. Biosystematics and medical importance of the Simulium amazonicum group and the *S. exiguum* complex in Latin America. *In* Service, M. W. (Ed.), *Biosystematics of haematophagous insects*. Oxford.

—— In press b. Biosystematics and distribution of simuliid vectors of human onchocerciasis in South America. *Memorias do Instituto Oswaldo Cruz*

Shelley, A. J. & Arzube, M. 1985. Studies on the biology of Simuliidae (Diptera) at the Santiago onchocerciasis focus in Ecuador, with special reference to the vectors and disease transmission. *Transactions of the Royal Society of Tropical Medicine and Hygiene* **79:** 328–338.

Smart, J. 1940. Simuliidae (Dipt.) from British Guiana and the Lesser Antilles. *Transactions of the Royal Entomological Society of London* **90:** 1–11.

—— 1942. Notes on Simuliidae (Diptera). *Proceedings of the Royal Entomological Society of London* (B) **11:** 46–50.

Stone, A. 1969. The black flies of Dominica (Diptera: Simuliidae). *Proceedings of the Entomological Society of Washington* **71:** 312– 318.

Strong, R. P., Sandground, J. H., Bequaert, J. C. & Ochoa, M. M. 1934. Onchocerciasis with special reference to the Central American form of the disease. *Contributions to the Department of Tropical Medicine and the Institute for Tropical Biology and Medicine* **6:** xiv + 234 pp.

Takaoka, H. 1983. 'Studies on blackflies in relation to the transmission of onchocerciasis in Guatemala', pp. 36–46. *In* Tada, I. (Ed), *A comparative study on onchocerciasis between South and Central Americas* vii + 79 pp. Kumamoto.

Tidwell, M. A., Tidwell, M. A., Munos de Hoyos, P. & Corredor, A. 1980. *Simulium exiguum*, the vector of *Onchocerca volvulus* on the Rio Micay, Colombia. *American Journal of Tropical Medicine and Hygiene* **29:** 377–381.

Trapido, H., D'Alessandro, A. & Little, M. D. 1971. Onchocerciasis in Colombia. Historical background and ecologic observations. *American Journal of Tropical Medicine and Hygiene* **20:** 104–108.

Vargas, L. 1942a. Notas sobre la terminalia de algunos simulidos de Mexico. *S. (E.) paynei n.n.* Vargas, 1942. *Revista del Instituto de Salubridad y Enfermedades Tropicales* **3:** 229–249.

—— 1942b. *Simulium fairchildi* Vargas, 1942 n.n., de Panama: Dipt. Simuliidae. *Revista Medicina de Mexico* **22:** 458–459.

—— 1945. Simulidos del Nuevo Mundo. *Monografias del Instituto de Salubridad y Enfermedades Tropicales, Mexico* **1:** vi + 241 pp.

Vargas, L. & Diaz Najera, A. 1951a. Nota sobre los simulidos de Mexico y su distribucion geografica (Diptera: Simuliidae). *Revista del Instituto de Salubridad y Enfermedades Tropicales* **12:** 89–100.

—— 1951b. Notas sobre sistematica y morfologia de simulidos. *Revista de la Sociedad Mexicana de Historia Natural* **12:** 123–172.

—— 1953a. Nota sobre el examen de tipos de simulidos descritos por el Prof. G. Enderlein. *Revista del Instituto de Salubridad y Enfermedades Tropicales* **13:** 137–149.

—— 1953b. *Simulium (Notolepria) gonzalezi* n. sp. (Insecta, Diptera). *Revista del Instituto de Salubridad y Enfermedades Tropicales* **13:** 235–241.

—— 1957. Simulidos Mexicanos. *Revista del Instituto de Salubridad y Enfermedades Tropicales* **17:** 143–399.

Vargas, L., Diaz Najera, A. & Martinez Palacios, A. 1946. Simulidos de Mexico. Datos sobre sistematica y morfologia. Descripcion de nuevos subgeneros e especies. *Revista del Instituto de Salubridad y Enfermedades Tropicales* **7:** [iv], 101–192.

Vulcano, M. A. 1967. *A catalogue of the Diptera of the Americas south of the United States*. **16.** Family Simuliidae. 44 pp. São Paulo, Brazil.

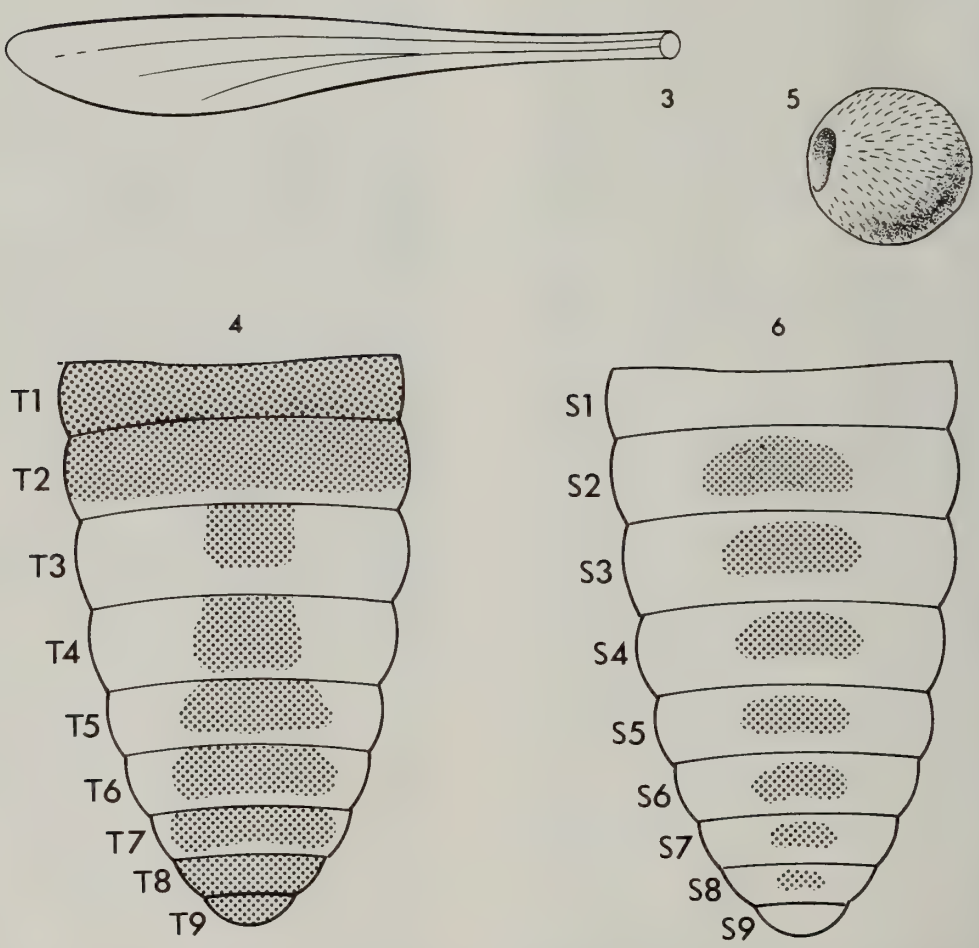
Wygodzinsky, P. 1950. Contribuciones al conocimiento de los Simuliidae argentinos. III. *Simulium dinellii* (Joan, 1912) y *Simulium wolffhugeli* (Enderlein, 1922). *Anales del Instituto de Medicina Regional de la Universidad Nacional de Tucuman* **3:** 75–97.

—— 1951. Sobre *Simulium jujuyense* Paterson y Shannon, 1927, *Simulium exiguum* Roubaud, 1906, y *Simulium opalinifrons* (Enderlein, 1934). *Anales del Instituto de Medicina Regional de la Universidad Nacional de Tucuman* **3:** 207–220.

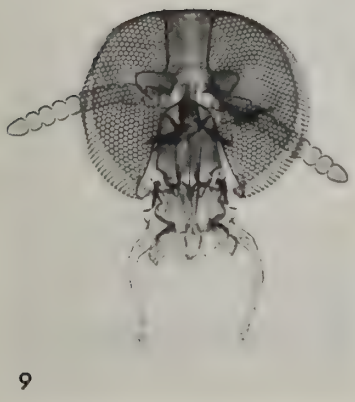
—— 1953. Sobre algunos simulidos de los paises andinos (Diptera). *Anales del Instituto de Medicina Regional de la Universidad Nacional de Tucuman* **3:** 321–337.

—— 1971. Descriptions and redescriptions of species of the blackfly genus *Simulium* from the Northern Andes (Simuliidae, Diptera). *American Museum Novitates* no. 2447: 1–38.

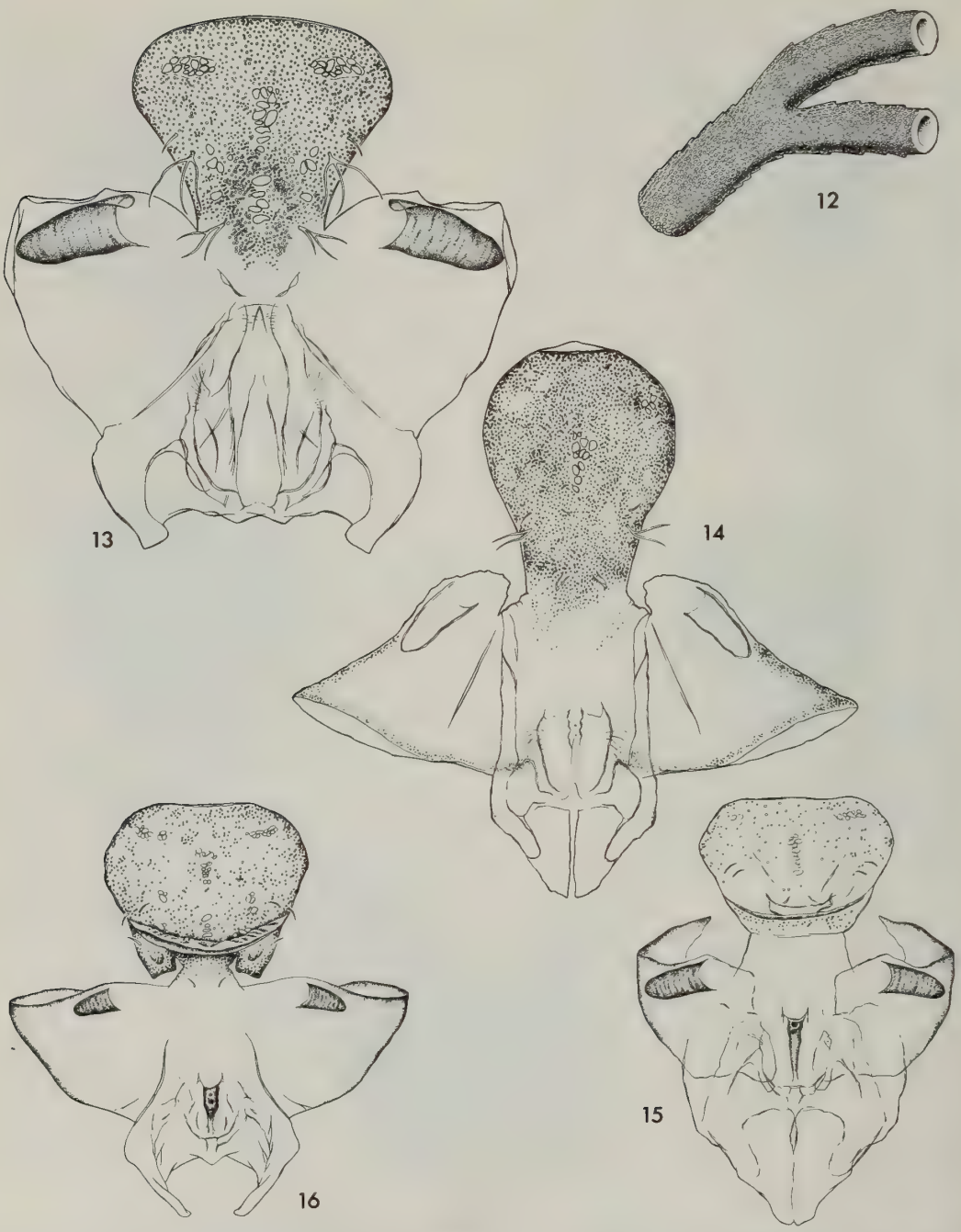
Zuluaga, F. N. & Yuill, T. M. 1978. Estudios epizootiologicos del virus de encefalitis venezolana en Providencia, Antioquia. *Revista del Asociacion Colombia de Medicina e Veterinaria Zootecnologica* **1:** 9–14.



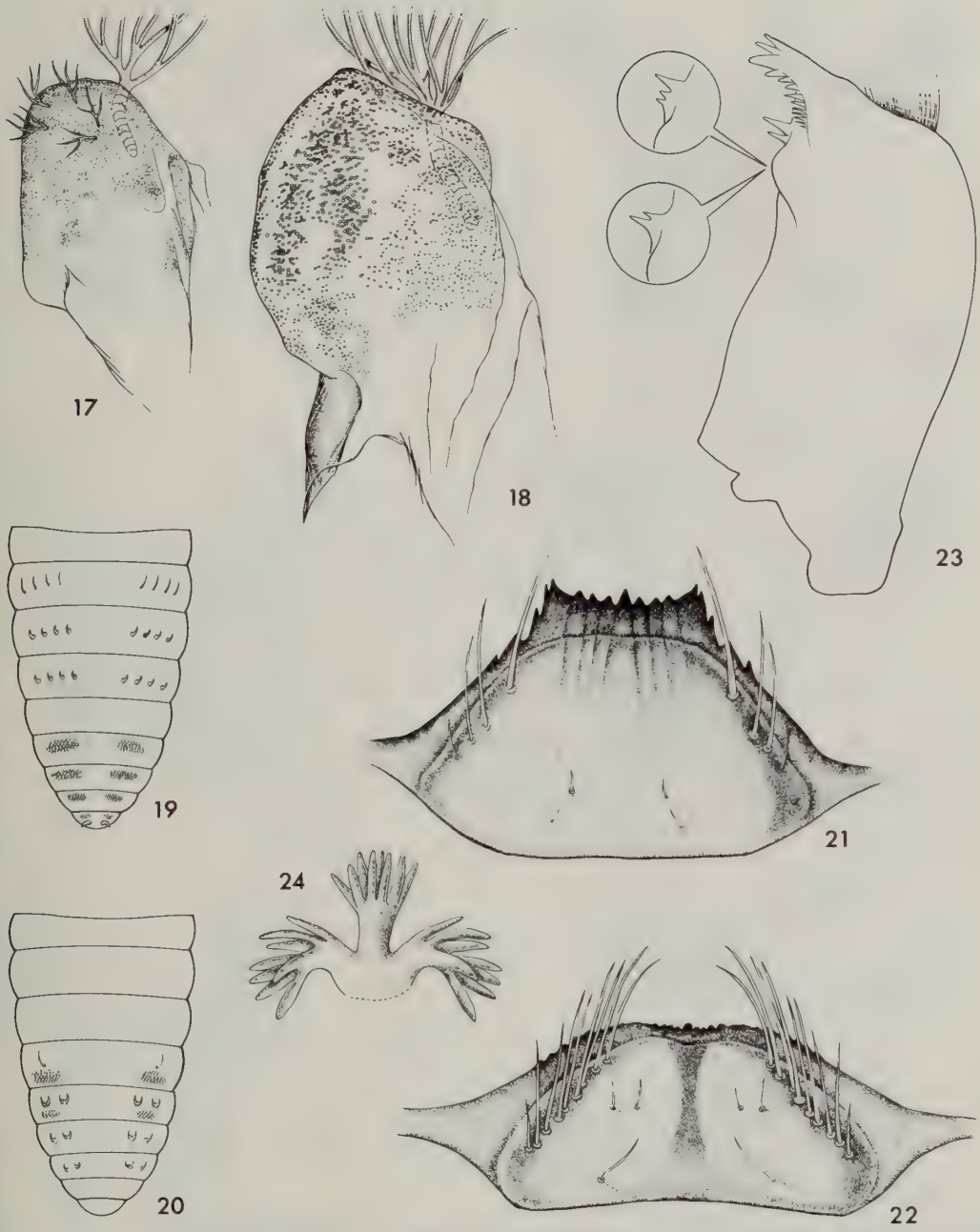
Figs 3–6 3, scale of leg of female *S. exiguum*. 4, dorsal view of female abdomen of *Simulium* showing position of tergal plates (shaded). 5, spermatheca of female *S. exiguum*. 6, ventral view of male abdomen of *Simulium* showing position of sternal plates (shaded).



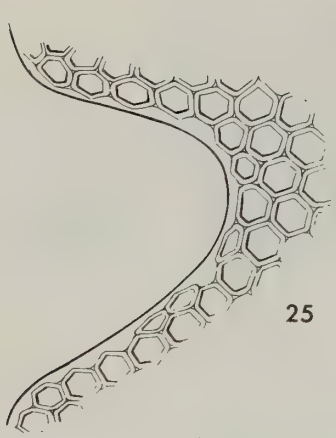
Figs 7–11 Anterior view of head of: (7) dichoptic female *S. exiguum*; (8) holoptic male *S. exiguum*; (9) dichoptic female *S. gonzalezi*; (10) dichoptic male *S. gonzalezi*; (11) holoptic male *S. gonzalezi*.

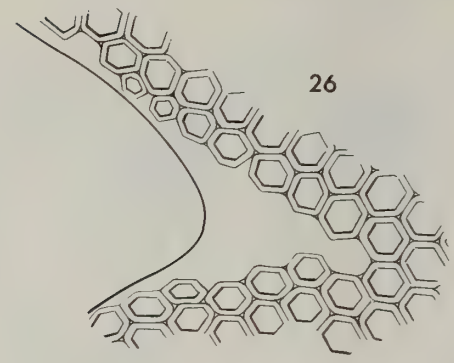


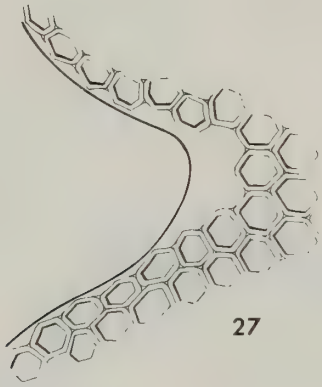
Figs 12–16 12, portion of gill filament of *S. exiguum*. 13, frontoclypeus of female pupa of *S. exiguum*. 14, frontoclypeus of male pupa of *S. exiguum*. 15, frontoclypeus of female pupa of *S. mexicanum*. 16, frontoclypeus of male pupa of *S. mexicanum*.

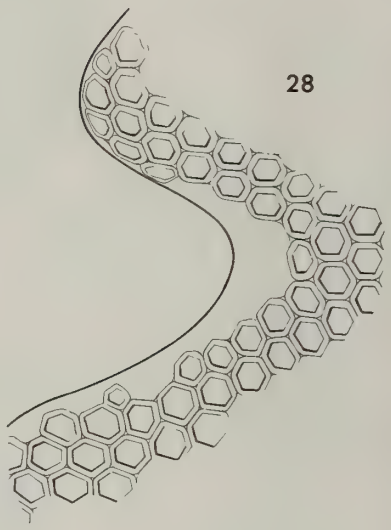


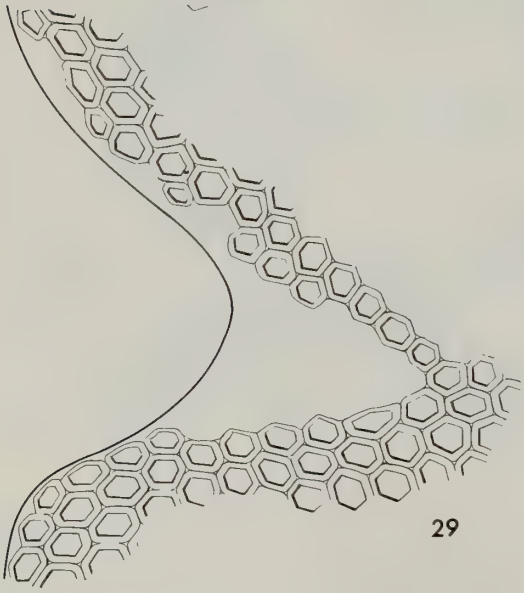
Figs 17–24 17, thorax of *S. exiguum* pupa. 18, thorax of *S. mexicanum* pupa. 19, dorsal view of pupal abdomen of *Simulium* showing chaetotaxy. 20, ventral view of pupal abdomen of *Simulium* showing chaetotaxy. 21, hypostomium of larva of *S. exiguum*. 22, hypostomium of larva of *S. mexicanum*. 23, mandible of *S. exiguum* larva; inset – variations in mandibular serrations of *S. bipunctatum*. 24, anal gills of *S. exiguum* larva.

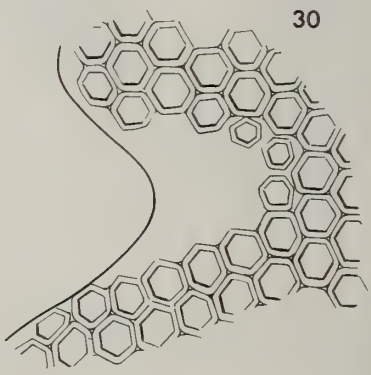












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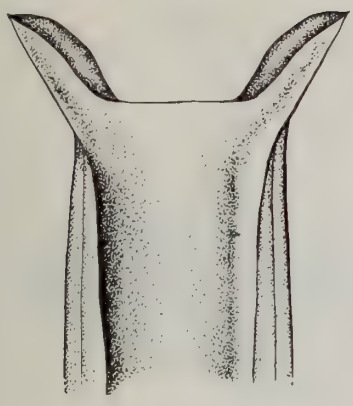

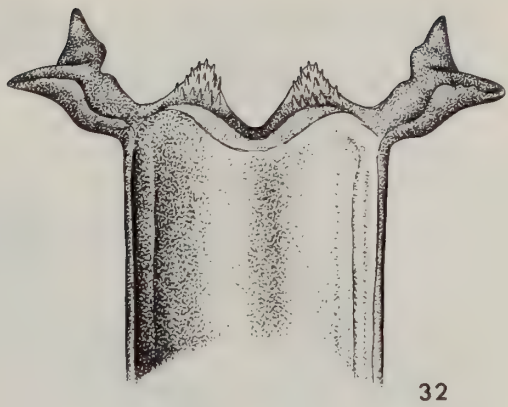

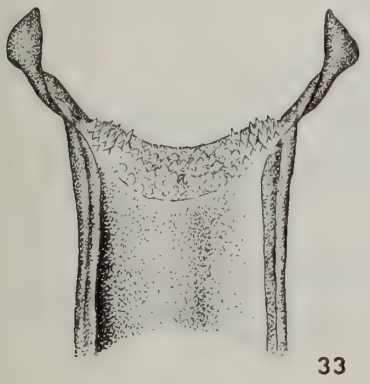

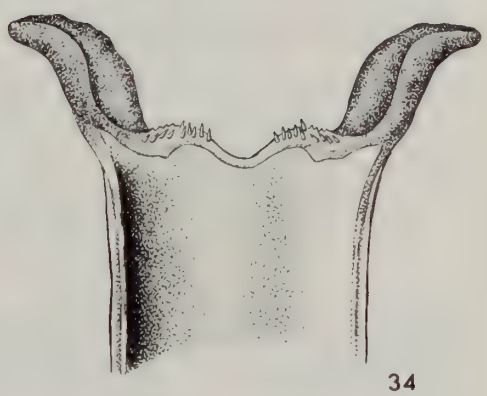

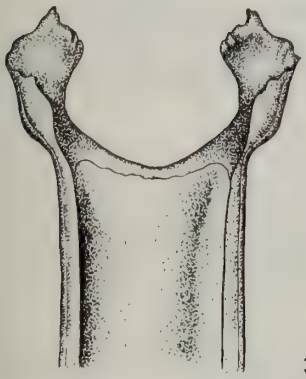

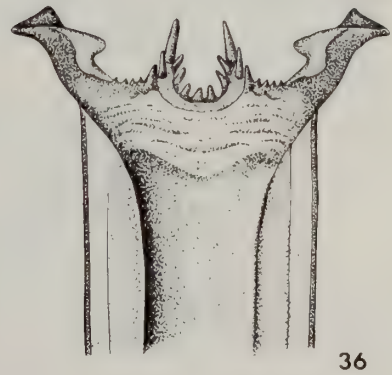

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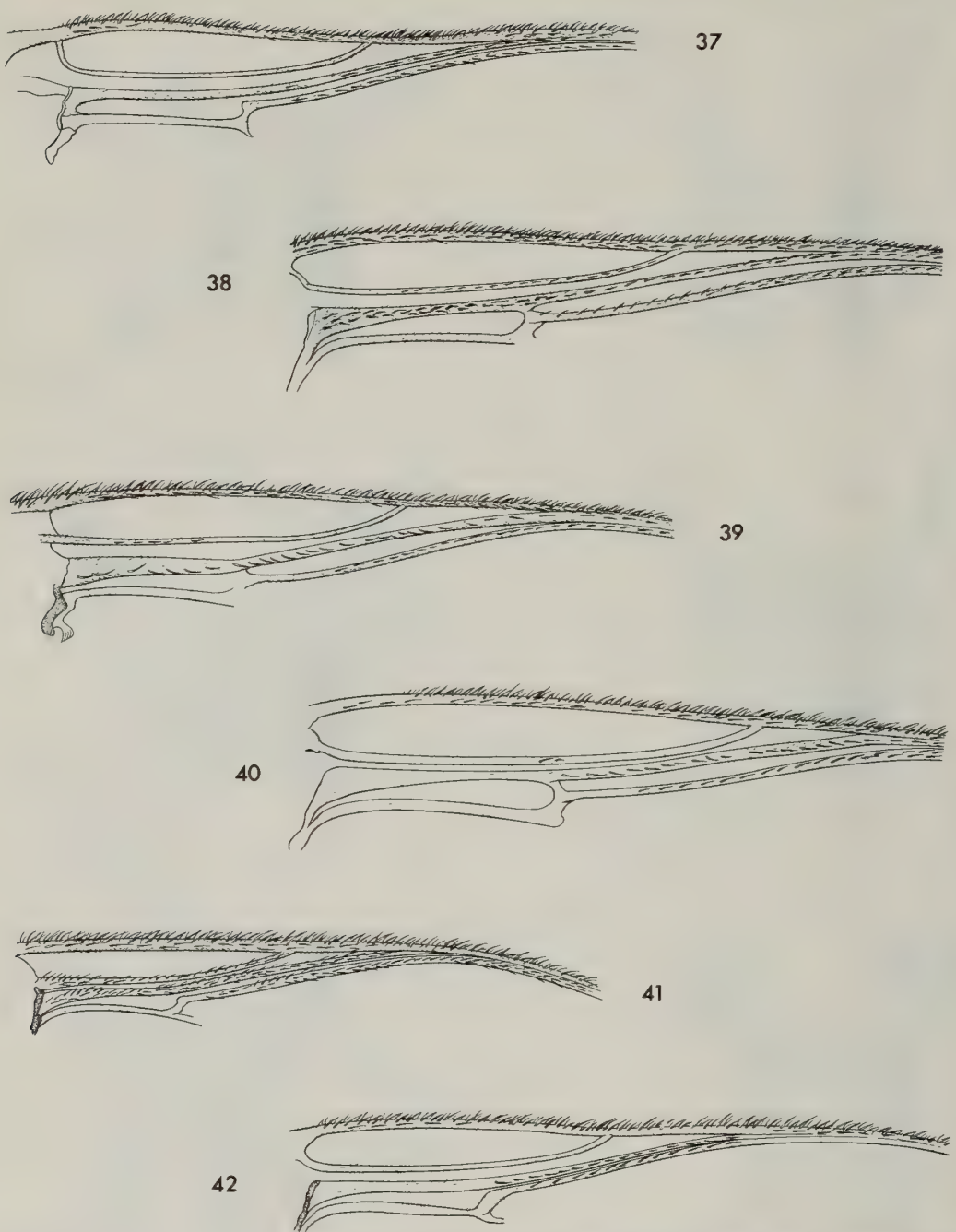

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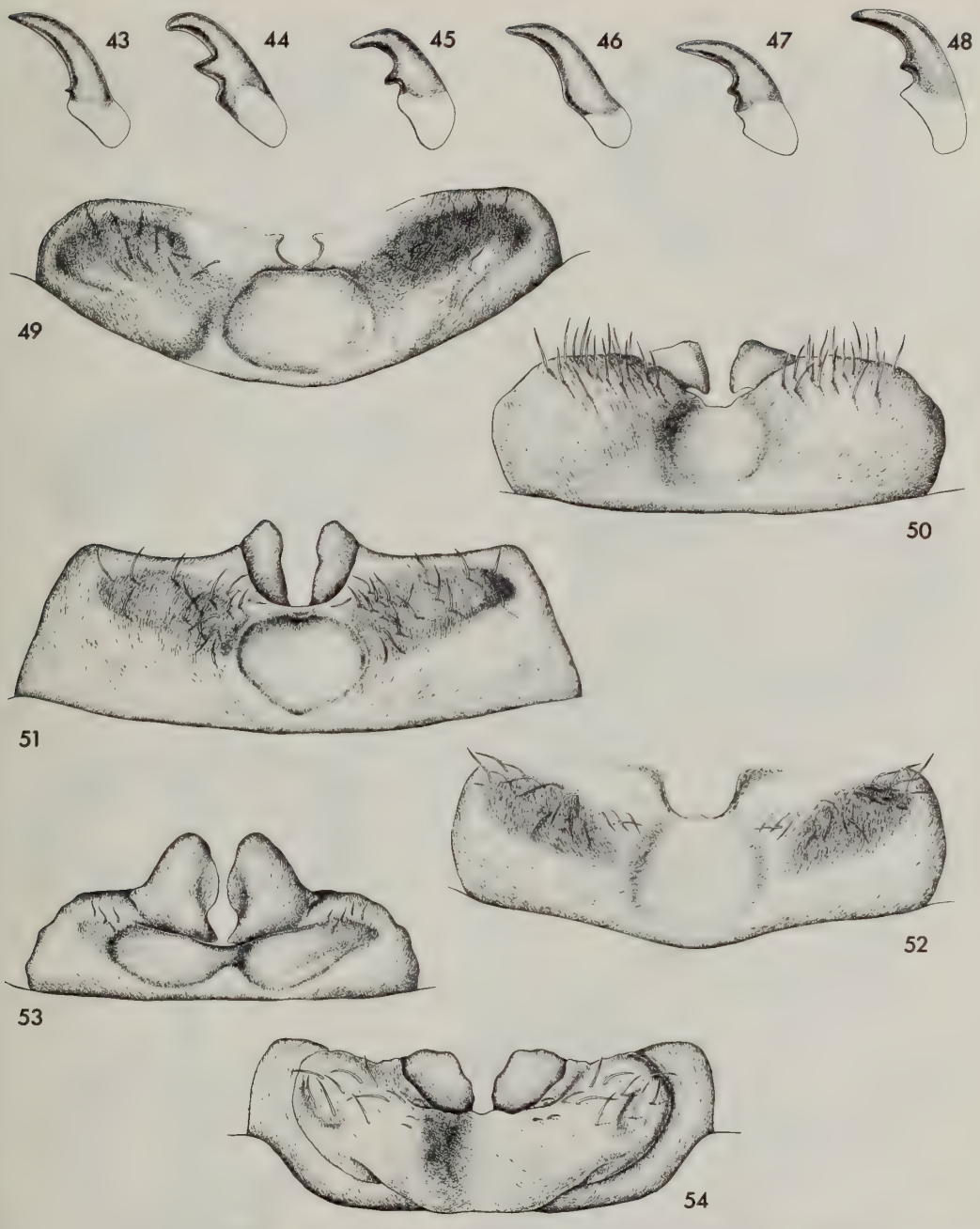

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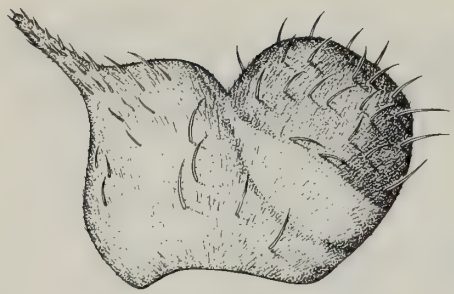

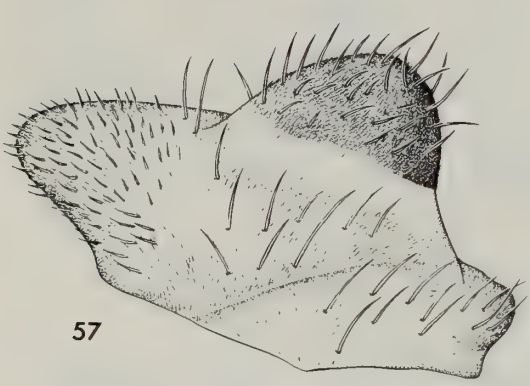

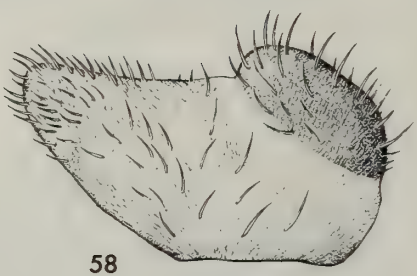

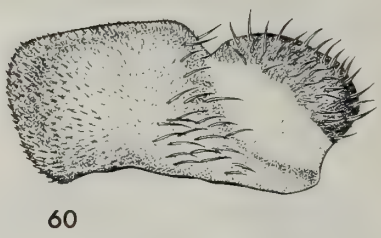

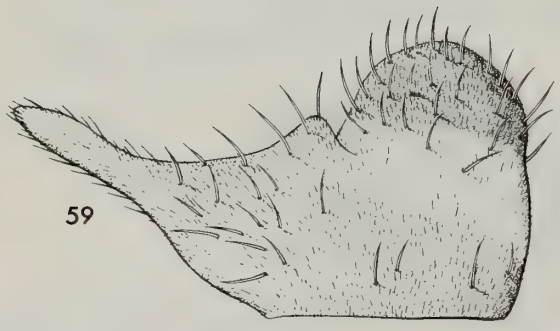

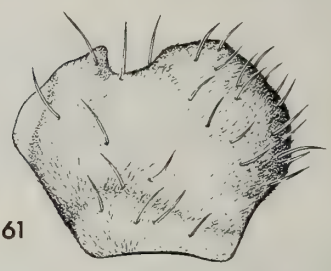

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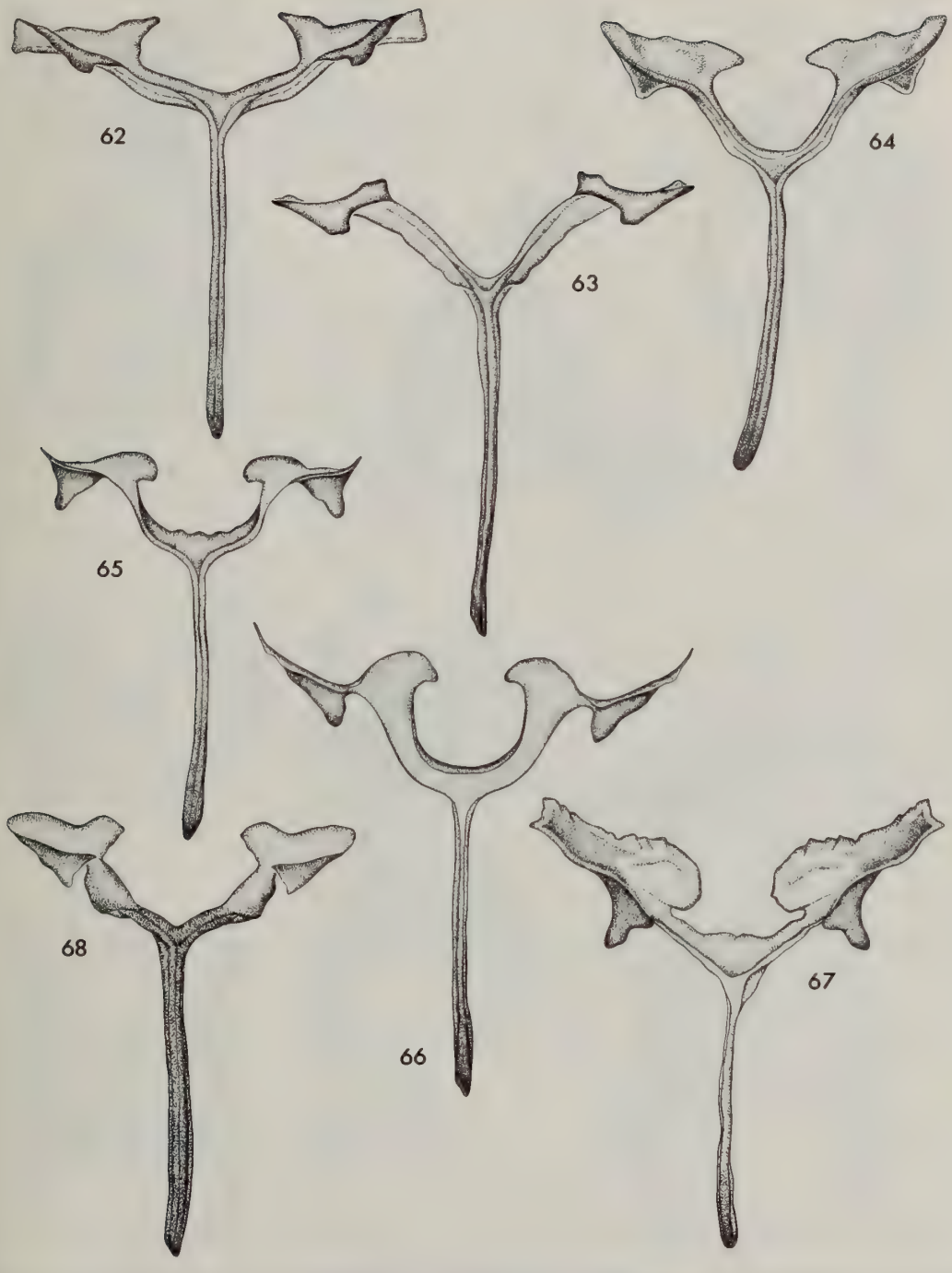

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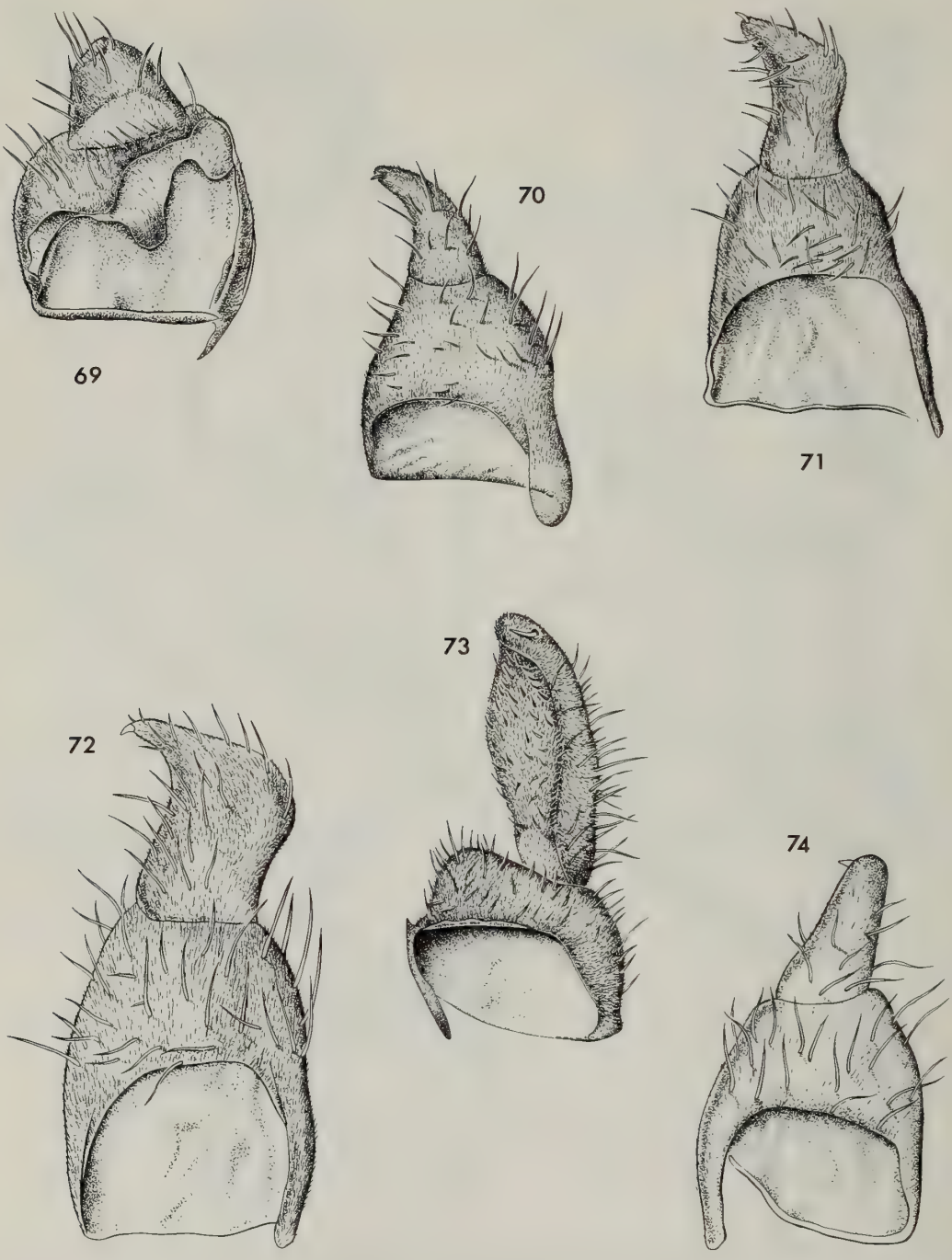

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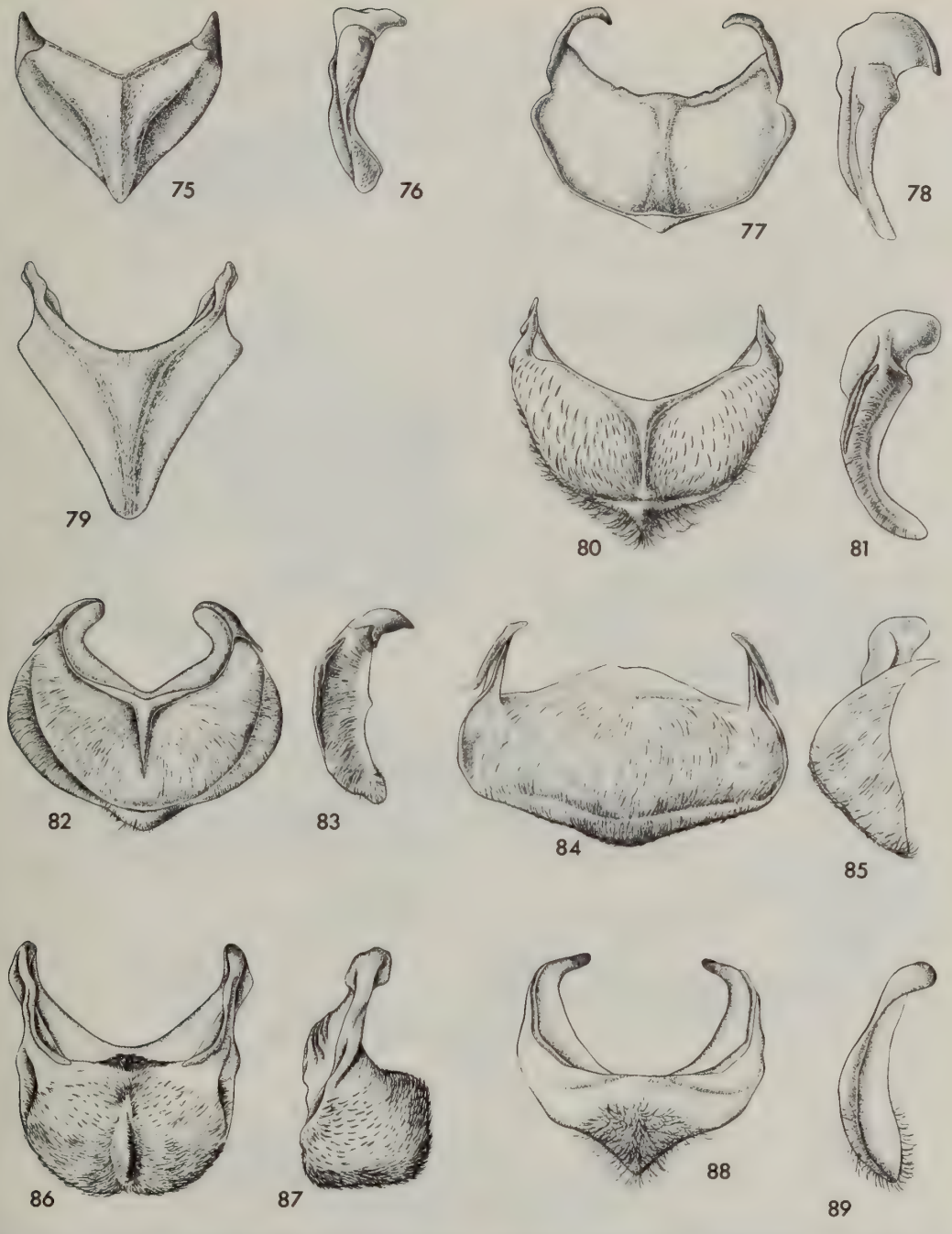

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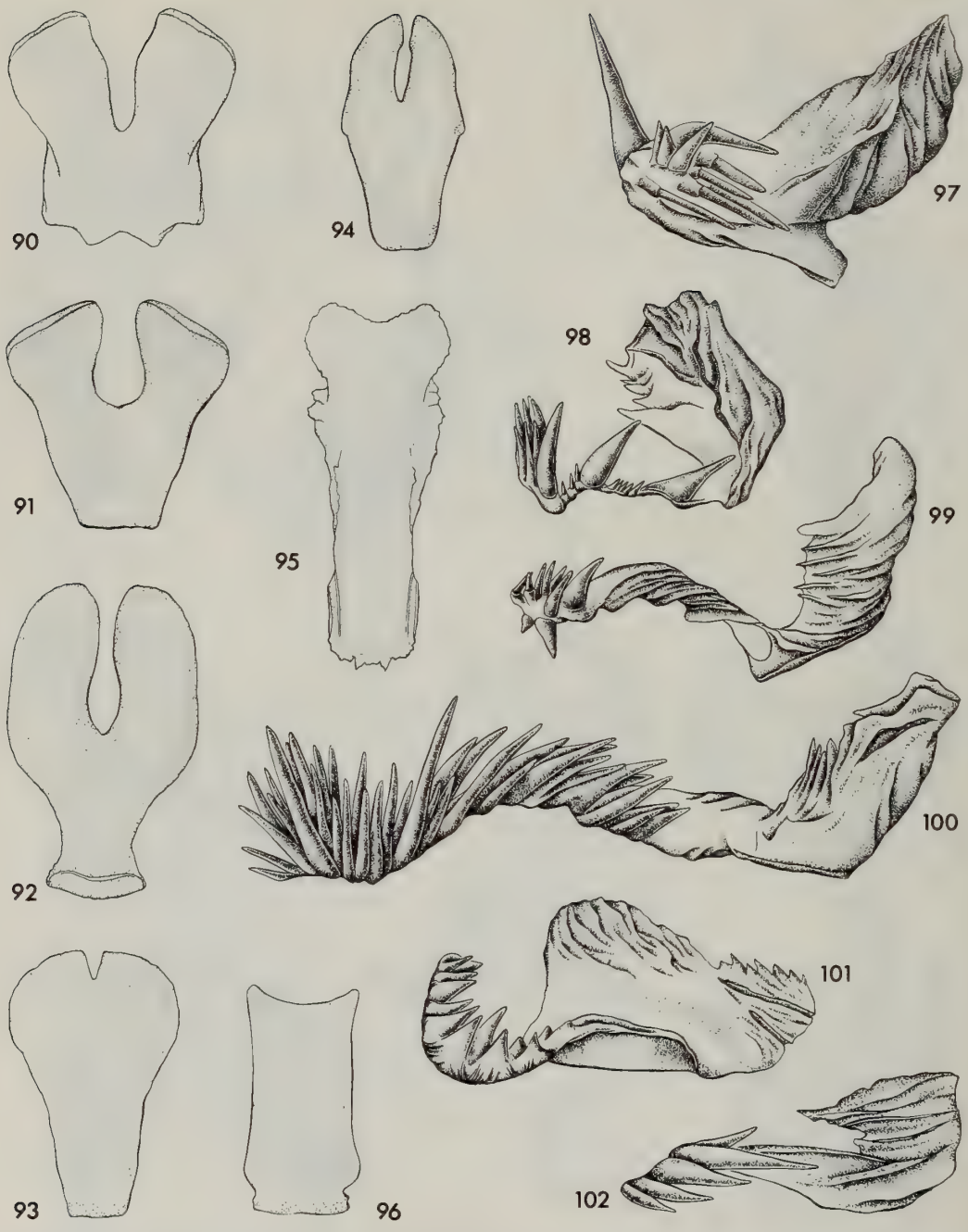

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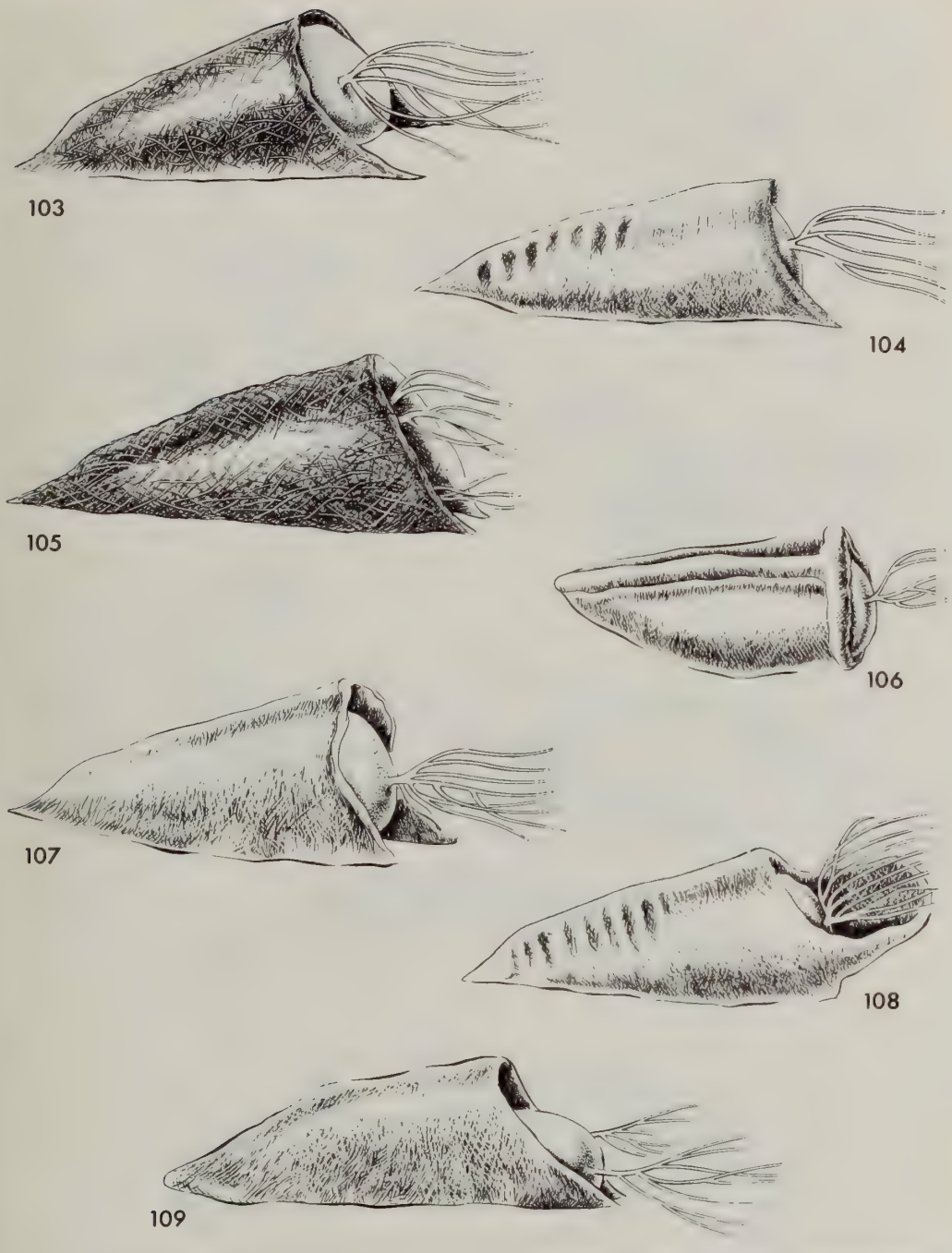

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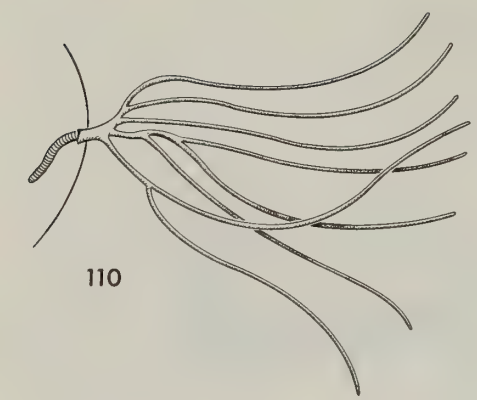

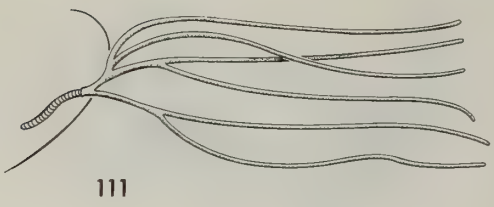

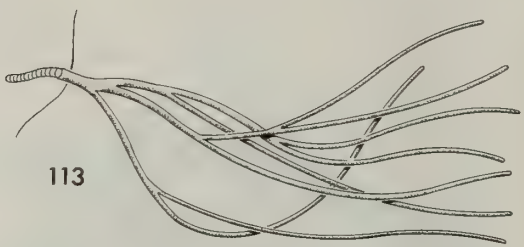

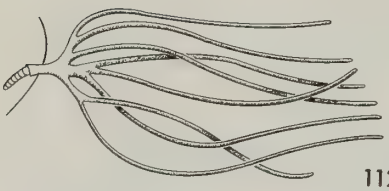

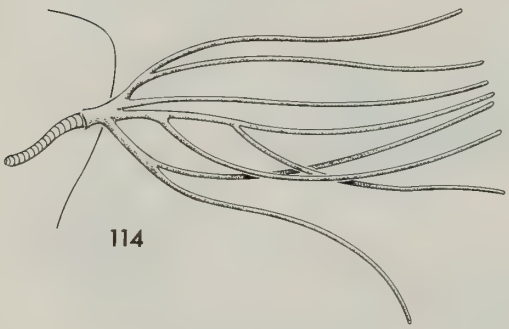

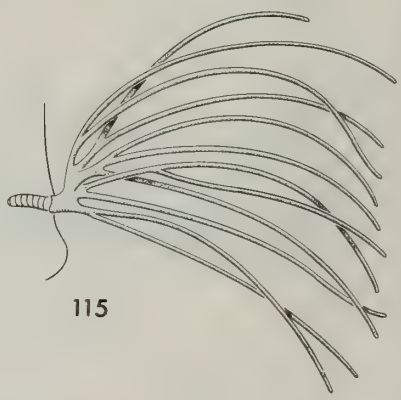

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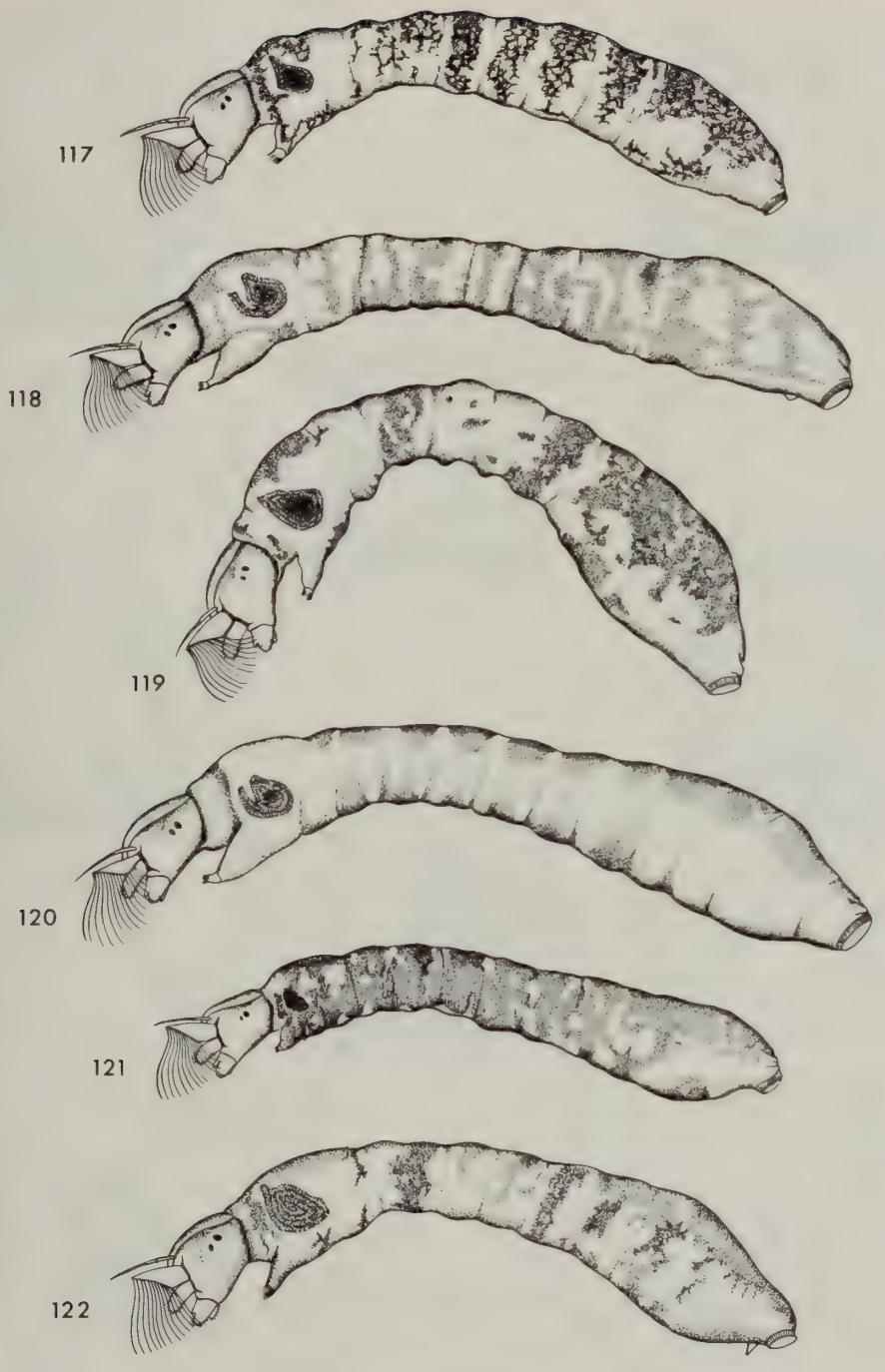

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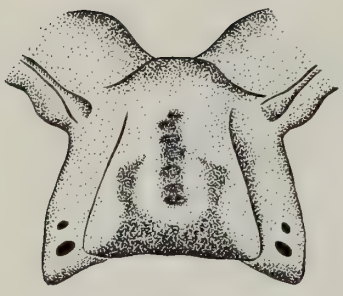

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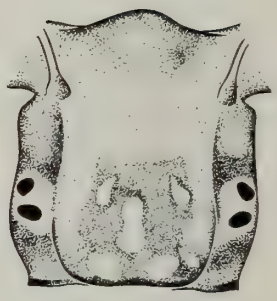

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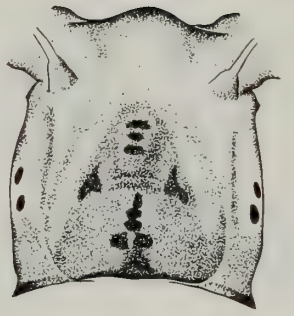

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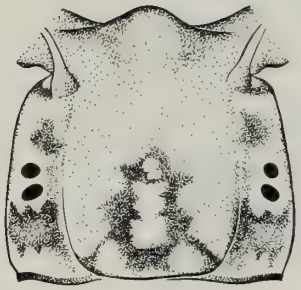

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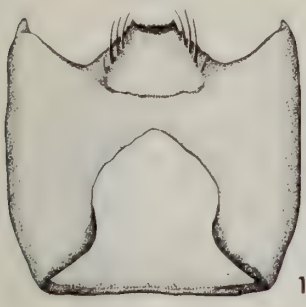

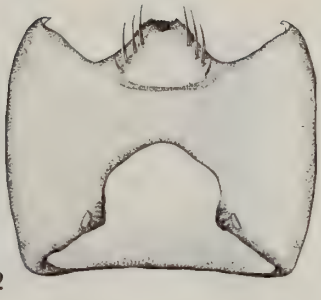

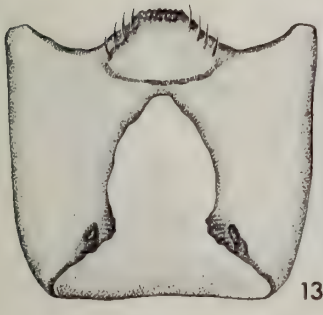

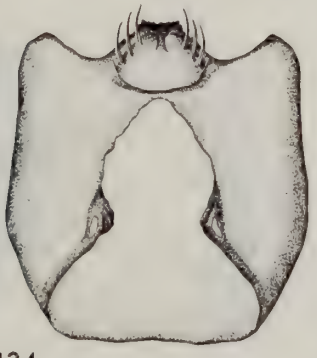

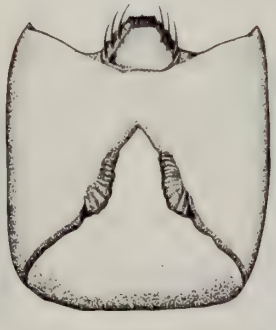

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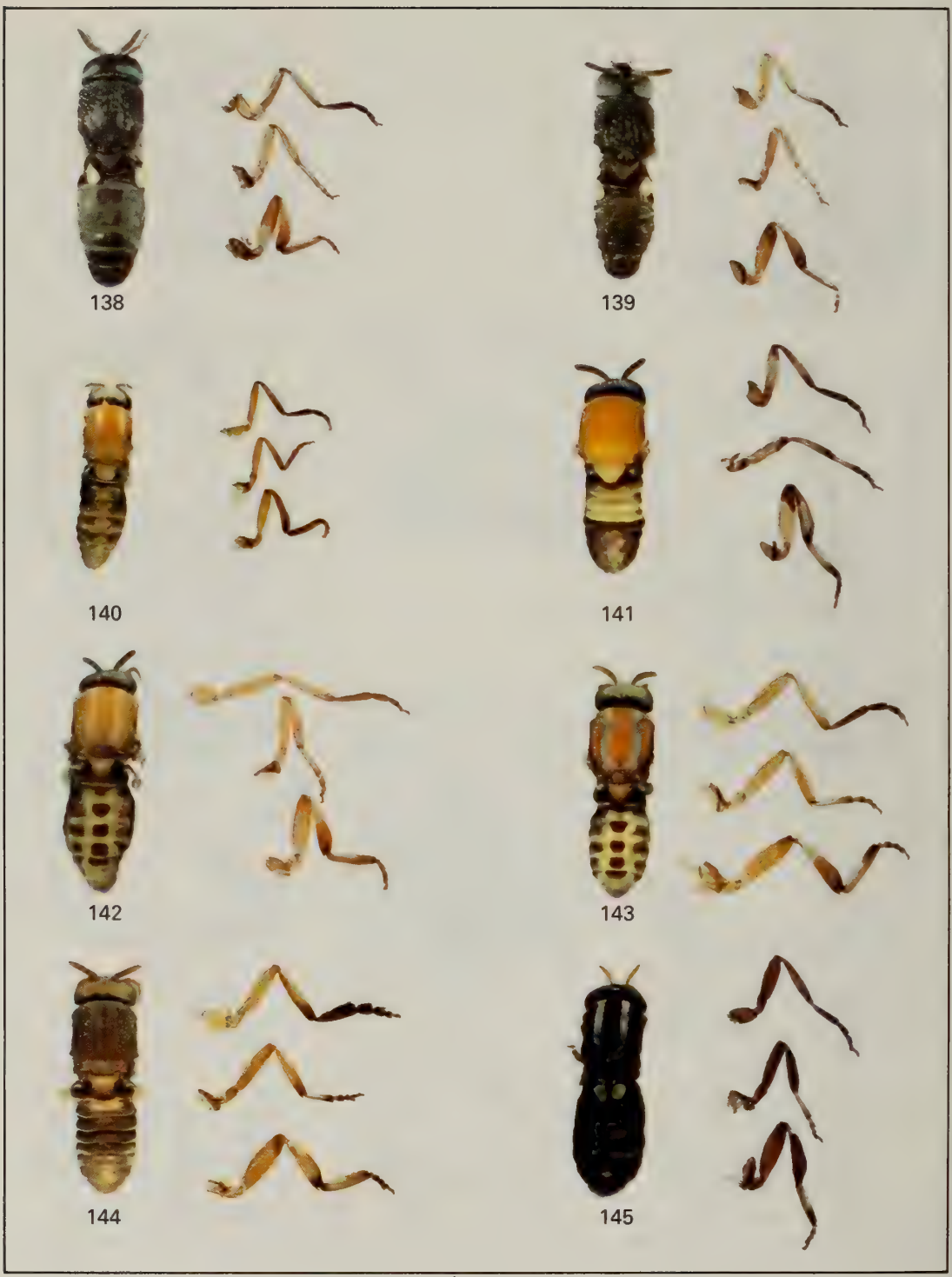

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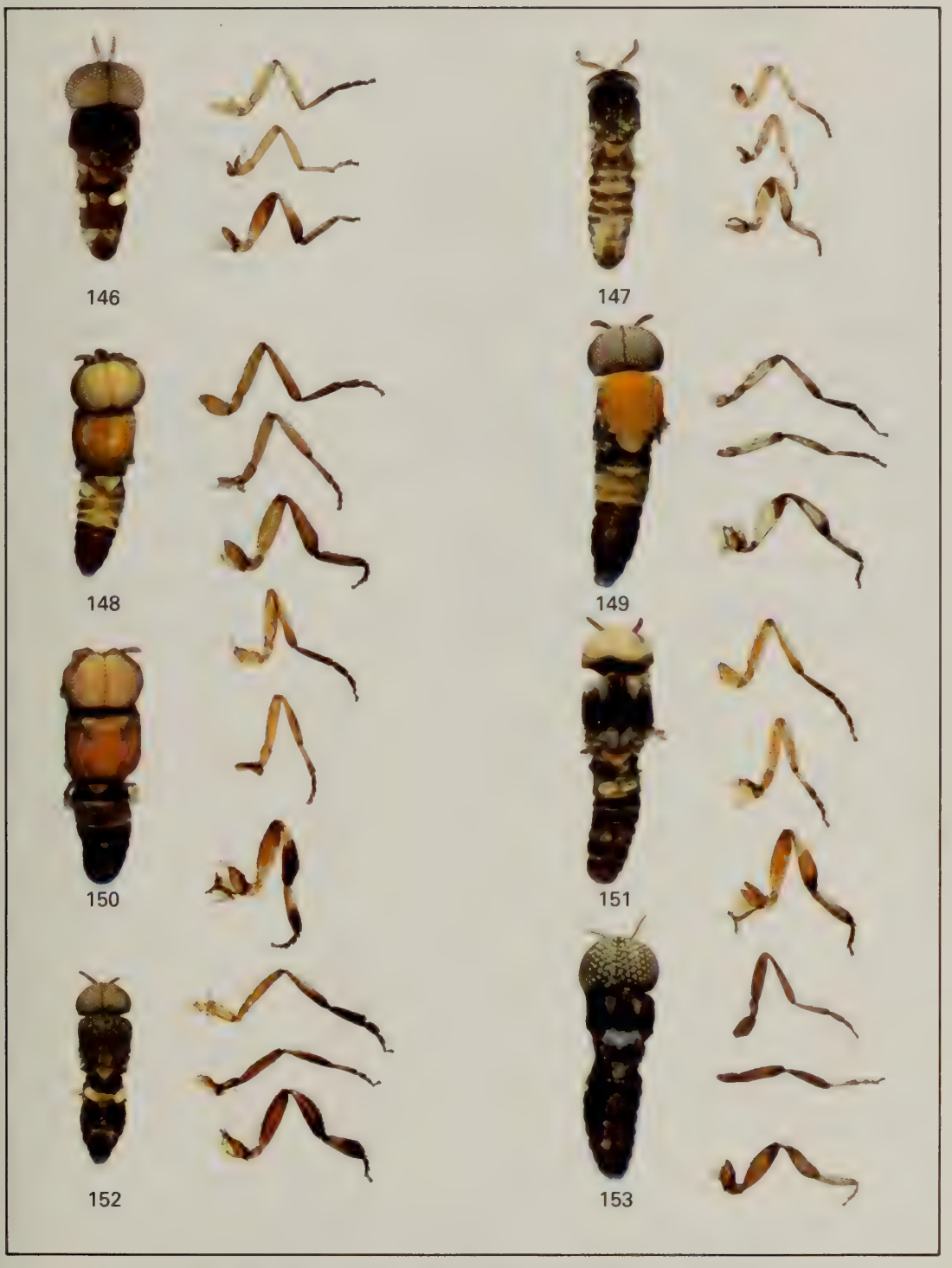

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Bulletin British Museum (Natural History)
ENTOMOLOGY SERIES
Vol. 58, No. 1, May 1989